LIFE CYCLE ENVIRONMENTAL IMPACT ANALYSIS OF ALTERNATIVE USES OF NATURAL GAS-FIRED EQUIPMENT IN BUILDINGS

by

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Submitted to the Graduate Faculty of the

School of Engineering in partial fulfillment

of the requirements for the degree of

Master of Science in Civil and Environmental Engineering

University of Pittsburgh

2002

UNIVERSITY OF PITTSBURGH

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ABSTRACT

LIFE CYCLE ENVIRONMENTAL IMPACT ANALYSIS OF ALTERNATIVE USES OF NATURAL GAS-FIRED EQUIPMENT IN BUILDINGS

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Cogeneration systems offer an opportunity to satisfy buildings' electrical and thermal loads, which could result in overall energy efficiency improvements and lower emissions to the environment. The objective of this research is to use a life cycle assessment framework to evaluate the environmental impact of using natural gas-fired technologies for heating, cooling and electrical energy generation in buildings. The natural gas-fired cogeneration systems examined were solid oxide fuel cell (SOFC), microturbine, and internal combustion engine (ICE). These systems were compared to two systems representing conventional practice: average electric generation mix in the U.S. and natural gas combined cycle electric generation (NGCC) for electrical energy; electric chillers (EC) and absorption chillers (AC) for cooling; and natural gas-fired boilers for heating.

A large commercial office building was used as a hypothetical case study. Typical building characteristics from the Commercial Building Energy Consumption Survey (Sezgan *et al.*, 1995) in combination with simulation software were used to obtain the building's electrical, heating, and cooling energy use. The building's energy use and process descriptions were used to construct life cycle models with the aid of life cycle assessment software.

The results of the research include analysis of the environmental impact from the use of the different energy systems in the building and comparisons between different operational strategies for the cogeneration systems: thermal load following (TLF) and electrical load following (TLF). Under the assumptions in this study, the main findings were that cogeneration systems performed better with ELF when the thermal load of the building was high; energy consumption and emissions were reduced when AC or combination of AC and EC were used for cooling with cogeneration systems, except for the SOFC, which performed equally well with EC only; and the 3-MW ICE (ELF) using combination of AC and EC, and the SOFC using EC (ELF) showed the best performance given the indicators and systems considered.

ACKNOWLEDGMENTS

I would like to thank Dr. Ries for his guidance, support, and for giving me the chance to work and learn from him. I would also like to thank Dr. Neufeld, Dr. Pohland, and Dr. Schaefer for their constructive cristism and review of the work.

I would like to especially thank my family for their support and encouragement throughout the hard years away from home and thank GOD for giving me the strength to make it!

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LIST OF ABBREVIATIONS

AC	Absorption chiller
AP	Acidification potential
AC/EC	Combination of absorption and electric chillers
CHP	Combined heat and power
EC	Electric chiller
ELF	Electric load following
GEMIS	Global emission model for integrated systems
GWP	Global warming potential
ICE	Internal combustion engine
LCA	Life cycle assessment
NGCC	Natural gas combined cycle
SOFC	Solid oxide fuel cell
TLF	Thermal load following
TOPP	Tropospheric ozone precursor potential

INTRODUCTION

The goal of this study is to evaluate natural gas-fired technologies for heating, cooling and electrical energy generation in buildings and compare these systems based on their energy use and pollutant emissions. The hypothetical case study was a large commercial office building located in Missouri, which is characteristic of the Midwest climate. Simulation software was used to generate the building's cooling, heating, and electrical energy usage. The building's energy usage data were used in conjunction with upstream process descriptions to create a life cycle assessment model to quantify, analyze, and compare the energy consumption and emissions from these systems. Life cycle assessment software was used to design the model and construct processes and scenarios to examine the different energy systems and operational strategies covered in this study.

The average commercial building in the U.S. requires electrical energy for lighting, office equipment, ventilation, and other mechanical and safety equipment; and thermal energy for space and domestic water heating and cooling. In conventional practice, the electrical power is supplied by a utility and is centrally generated and distributed through the power grid to the building. The thermal energy is supplied by combusting fossil fuel, typically natural gas, on-site. On the other hand, on-site generation of electricity offers an opportunity to satisfy the building's thermal loads. This could lead to overall energy efficiency improvements and lower emissions.

The cogeneration processes used in the model for energy production were solid oxide fuel cell (SOFC), microturbine, and two sizes of internal combustion engines (143-kW ICE and 3-MW ICE). These cogeneration systems were compared to U.S. average electric generation mix and natural gas-fired combined cycle (NGCC). The U.S. average electric power generation and the natural gas-fired combined cycle electric generation were considered "baseline" because they represent conventional practice. The cogeneration processes, on the other hand, were operated to generate the thermal energy usage of the building, thermal load following (TLF), in one scenario, and the electric energy usage of the building, electrical load following (ELF), in another.

While following the thermal load of the building, the cogeneration processes generated electricity, which was used to fulfill some or all of the electric energy usage of the building. Likewise, while following the electric load of the building, the cogeneration processes generated heat, which was used to fulfill some or all of the thermal energy usage of the building.

In the baseline scenarios, the cooling energy use of the building was satisfied by either electric chillers, driven by electricity generated from the U.S. average electric generation mix or natural gas combined cycle, in one case, or by absorption chillers, driven by the heat from gas boilers, in another case. A gas boiler was used for thermal energy for space and domestic hot water.

In electric load following scenarios, three different systems were examined for cooling energy use of the building:

(1) Electric chillers,

(2) Absorption chillers, or

(3) A combination of electric and absorption chillers.

In the first case, cogeneration processes were operated to meet the equipment and lighting load of the building, which included electric chillers for the cooling load. In the second case, cogeneration processes were operated to meet the equipment and lighting load of the building, and the cooling load was met by absorption chillers, which were driven by the otherwise wasted heat from the cogeneration process. In the third case, cogeneration processes were operated to meet the equipment and lighting load of the building, and the cooling load was met by combination of electric and absorption chillers (the co-generated heat was utilized to run the absorption chillers). Any unmet thermal demand for heating was satisfied by gas boilers in all cases.

In thermal load following scenarios, the cooling energy use of the building was satisfied by absorption chillers run by heat from cogeneration processes. Any unmet electrical power was satisfied by electricity generated from the U.S. average generation mix.

The environmental impact of using the energy systems to generate thermal and electrical energy for the hypothetical office building was examined for the three scenarios, baseline, TLF, and ELF. The environmental impact indicators chosen for the analysis were:

1. Primary energy consumption;
2. Global warming potential (GWP);
3. Tropospheric ozone precursor potential (TOPP); and
4. Acidification potential (AP).

The environmental impact analysis was carried out in annual, daily, and hourly basis. For daily and hourly analysis, three months were chosen: January, representing heating month, and May and August, representing cooling months.

Chapter 1 provides some background information on motivation and approach for the study, and also, a literature review. Chapter 2 contains details on the life cycle assessment study, including energy systems and scenario descriptions. Chapter 3 includes a description of the building characteristics, energy load profiles, and energy production from the cogeneration systems. Chapter 4 contains the results and analysis on the environmental impact from the use of energy systems in the hypothetical building, which includes comparisons between cogeneration systems operated in thermal load following (TLF) mode and conventional systems, i.e., average electric generation mix and NGCC. Chapter 5 contains the results and analysis on the environmental impact from the use of energy systems in the hypothetical building, which includes comparisons between cogeneration systems operated in electrical load following (ELF) mode and conventional systems, i.e. average electric generation mix and NGCC. Chapter 6 provides the conclusion of this study and suggestions for future research.

The appendices contain raw data used in the construction of the model as well as results obtained by running the life cycle assessment software.

1.0 BACKGROUND & APPROACH

This chapter includes the following sections:

Section 1.1: Background

The section includes background information on natural gas use in commercial buildings, drivers and restrictions for on-site power generation, and the importance of using a life cycle assessment (LCA) framework in the study.

Section 1.2: Study Approach

The section provides an overview of the study approach, energy systems examined, operational strategies investigated, and environmental impact indicators chosen for the analysis.

Section 1.3: Literature Review

The section includes a summary of some of the literature reviewed at the beginning of the study, which covers some of the life cycle assessment (LCA) studies and combined heating and cooling (CHP) studies done in this field.

1.1 Background

The Energy Information Administration (EIA) of the Department of Energy estimates that commercial buildings in the United States consume 5,321 trillion Btu of energy for space and water heating, cooling, and lighting, of which 1,946 trillion Btu is natural gas (about 37%) (U.S.DOE, 1995). Also, commercial buildings consume 2,6608 trillion Btu of electricity that results in 7,873 trillion Btu of primary energy use, 235 trillion Btu in fuel oil, and 533 trillion Btu in district heating. This results in a total annual energy expenditure of $70 billion for commercial buildings in the United States.

In commercial buildings in the United States, natural gas is recognized as the principal fuel for space and water heating, with electricity generated off-site used for cooling loads, lighting needs, and equipment such as computers. In addition, natural gas-fired equipment can also be used for absorption cooling and power generation in buildings. This makes natural gas the dominant primary energy source for commercial buildings in the United States.

Because electricity restructuring favors lower electric costs and more efficient generation processes, natural gas is expected to increase its share of power generation capacity from 16% in 1999 to 36% in 2020 (U.S. DOE, 2000). One advantage of natural gas systems is their high conversion efficiencies compared to coal-fired power plant. For example, about 10% of the overall energy content of fuel consumed in power production is natural gas, which results in about 15% of net electricity generated by the electric power industry, whereas, 56% of the fuel consumed in making electricity in the U.S. is coal, which results in about 52% of the net electricity generated (Spath and Mann, 2000). The EIA estimates that 92% of the new generation capacity, including distributed generation, will be fueled with natural gas, and that distributed generation[1] and fuel cells are expected to represent 3.5% of new generation capacity added by 2020 (EIA, 2000).

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[1] Distributed generation refers to small power generation units (typically less than 30 MW) strategically located near consumers and load centers that provide benefits to customers and support for economic operation of the existing power distribution grid (Liss and Kincaid, 1999).

Another advantage of the use of natural gas for electricity production is lower environmental impact as compared to electricity generated from coal and oil-fired systems. Natural gas has a lower sulfur and nitrogen content than coal resulting in lower acidification and ozone precursor potentials, as well as a lower carbon to hydrogen ratio.

Distributed generation will play a role in supporting available capacity to meet peak power demands, provide critical customer loads with emergency standby power, improve power quality, and provide low-cost total energy in combined heat and power (CHP) applications (GRI, 1999/0054). In addition, using gas-fired cogeneration systems offer valuable benefits both from an environmental perspective (emit fewer pollutants than conventional coal- and oil-fired systems) and energy efficiency perspective (recapture much of the otherwise wasted thermal energy and use this energy for a variety of purposes, such as space and water heating). A detailed discussion of the cogeneration technologies is given in Chapter 2.

Historically, most power generation was owned by utilities operating under regulatory control; in 1997, about 11 percent of capacity was owned by non-utility entities, most of which use natural gas fired equipment (GRI, 1999/0054). The majority of the gas-fired equipment are large (over 25 MW) simple-cycle and combined-cycle gas turbine power plants. The main drivers favoring large gas combined cycle turbine power plants are low up-front costs, low environmental impact, and high efficiency (50-60%) and availability (93.3%) compared to conventional power plants whose availability averaged 85.9% in 1986-1990 (GRI, 1999/0054).

With electric utility restructuring, smaller gas-fired cogeneration systems (less than 25-MW) provide opportunities for reliable and efficient on-site power generation. The market for small-scale power generation has not developed in the past two decades in the same way as large systems mainly because of negative scaling effects (higher total costs with decreasing size), legitimate technical issues, and competitive responses from electric utilities trying to avoid customer loss (GRI, 1999/0054).

Unlike large turbine systems competing against higher priced coal-fired power plants, these emerging small cogeneration systems compete against products featuring lower capital costs, lower emissions, lower maintenance needs, and lower noise emissions (GRI, 1999/0054).

Currently, on site generation is often accomplished with cogeneration, the sequential production of both electrical (or mechanical) energy and thermal energy (Hay, 1988). Two thirds of the primary energy consumed by conventional electric power plants is lost to the environment as heat. In contrast, cogeneration systems, also known as Combined Heat and Power (CHP) systems capture much of the otherwise wasted thermal energy and use this energy for a variety of purposes, such as space or water heating (Hay, 1988). Gas-fired cogeneration systems are an attractive option from both an environmental and an energy efficiency standpoint.

Thermal energy use of a commercial or institutional end-user often consists of hot water or low pressure steam energy use in the winter and cooling energy use in the summer. Heat from the prime movers is often used in a single-stage steam or hot water absorption chiller. This option allows the CHP system to operate continuously throughout the year while maintaining a good thermal load without the need to reject heat to the environment (ONSITE SYCOM, 1999).

Cogeneration applications are driven by grid price and installed cost, but emissions can provide a strong barrier to implementation, especially in non-attainment areas. As with continuous power applications, these units will run on a nearly continuous basis, typically at least 6,000 hours per year (GRI, 1999). Some of the drivers and restrictions for on-site power generation are summarized in Table 1.

Table 1: Drivers and Restriction for On-site Power Generation

Drivers for On-site Power Generation	Restrictions for On-site Power Generation
Electric rates for grid power are favorable for on site generation because residential and commercial sectors pay significantly more for electricity, on average, than industrial customers (Little, 2000).	Non-traditional market for on site generation, which requires new approaches to ownership and operation, as well as permitting, interconnection standards and similar issues, which need to be addressed to facilitate access to this market (Little, 2000).
Reduction in energy ($/kWh) and electric demand ($/kW) charges.	Conventional generating technology tends to be more economical in large sizes (Ellis and Gunes, 2002).
Improved power quality and reliability, potential source of emergency or standby power (GRI, 1999/0045).	Conventional generating technology tends to require larger, more skilled maintenance staff than is available in many building applications (Ellis and Gunes, 2002).
Loads and load factors[2] are well suited to several micropower[3] technologies, especially high-load factor buildings, such as hotels and hospitals (Little, 2000).	Many buildings types have low load factors (i.e. retail, office) (Little, 2000). Conventional generating technology is most efficient in large sizes when operating near full load (Ellis and Gunes, 2002).
Reduction in transmission and distribution electrical line loses (Liss and Kincaid 1999).	Utility interconnection requirements for CHP systems could be costly and laborious. Also, the "back-up" charges from local utilities, during the down time for maintenance of CHP, could be excessive (ASC, 2000).
A source of energy-efficient thermal energy, when used in a combined heat and power (cogeneration) application (Liss and Kincaid 1999).	
Low overall emission rates per kWh produced.	Noise and environmental emissions restrict the potential sites for conventional generating technology (Ellis and Gunes, 2002).

[2] Load factor is the annual electricity consumption divided by the peak power demand *8760 hours/year. It is a measure of the average demand relative to the peak demand (Little, 2000).

[3] Micropower is defined as microturbines, fuel cells and reciprocating engines under 1 MW (Little, 2000).

Average commercial buildings in the U.S. require electrical energy for lighting, office equipment, ventilation, and other mechanical and safety equipment; and thermal energy for space and domestic water heating and cooling. In conventional practice, the electrical power is supplied by a utility and is centrally generated and distributed through power grid to the building. The thermal energy is supplied by combusting fossil fuel, typically natural gas, on-site. On the other hand, on-site generation of electricity offers an opportunity to satisfy the building's thermal loads. This could lead to overall energy efficiency improvements and lower emissions.

Using life cycle assessment (LCA) as a tool, which considers all elements associated with materials and fuels used in the processes studied, such as exploration, processing, transportation, transmission, distribution and use, will provide a framework for understanding and comparing energy systems used for electrical and thermal generation and their impact on the environment. An understanding of the performance of these systems is a key not only for consumers but also for decision makers in energy policy and environmental regulation.

The environmental impact assessment of using energy (thermal and electrical) generation systems will give more insight into how the different stages associated with energy production and use affect our lives and the environment. Environmental impact could be global such as greenhouse gases, regional, such as acid rain, or local, such as smog formation. Also, environmental impact can assess the availability of natural resources, such as primary energy consumption. Understanding the environmental impact associated with the use of energy systems will aid decision makers in creating policies that necessitate the sustainable use of natural resources and encourage technologies that use energy efficiently. In addition, understanding the environmental impact associated with the origins and fate of pollutants resulting from energy generation systems, will not only help in assessing the damage resulting from their use on humans, animals, plants, lakes, atmosphere etc., but also help in addressing the problem at its source and finding means to decrease or eliminate the impacts.

1.2 Study Approach

The objective of this study is to use a life cycle assessment framework to evaluate the potential for reducing the environmental impact of energy use in buildings, which will encompass all upstream and downstream processes, such as extraction, transportation, processing, transmission, distribution and use. This study examined and analyzed the relative environmental impacts and energy efficiencies of natural-gas fired cogeneration technologies for providing space and domestic water heating, cooling, and electrical power for equipment and lights in buildings and compare them to that of average U.S. central power plant as well as natural gas combined cycle power generation plant.

The hypothetical case study was a commercial office building with an area of 100,000 square feet and the location chosen for this study is Columbia, Missouri, which is characteristic of a Midwest climate. Data from literature in combination with energy simulation software were used to obtain the electrical, heating, and cooling energy usage of the building. The electrical, heating, and cooling energy usage of the building is detailed in Chapter 2.

Process descriptions from literature were used to define systems' characteristics, energy efficiencies, and emissions and were also used to construct the life cycle assessment (LCA) model. LCA software, GEMIS (Global Emission Model for Integrated Systems), was used to analyze different scenarios as well as to provide some basic data on upstream energy carriers (process chains and fuel data). A set of scenarios which included electrical loads for equipment and lighting, cooling, and thermal loads for space conditioning and water heating were designed for the building. Three types of electric generation models were used for the analysis to supply electric energy use of the building:

1. U.S. average electric generation mix
2. A 100% mix natural gas combined cycle electric generation (NGCC)
3. On-site cogeneration.

Thermal energy use was supplied by:

1. Natural gas-fired boilers

2. On-site cogeneration

Cooling energy use was supplied by:

1. Absorption chiller (AC)
2. Electric chiller (EC)

The cogeneration processes studied were a solid oxide fuel cell (SOFC), microturbine, and internal combustion engine (ICE). Onsite cogeneration processes could be operated in various combinations to optimize the electrical or thermal production from the processes. Three basic operational strategies were examined in the scenarios:

(a) Baseline,

(b) Thermal, and

(c) Electrical.

Two options, one that represented conventional practice and on that represented high efficiency available technology were U.S. average electric generation mix and natural gas-fired combined cycle (NGCC), respectively, which satisfied the electric load of the building in the baseline scenarios. Figure 1 shows an illustration of the baseline scenario. The cogeneration processes were operated to meet the thermal energy use of the building in one case and to meet the electrical energy use on another. When the cogeneration processes were operated to meet the thermal load of the building, i.e. thermal load following (TLF), they co-generated electricity, which could be used to satisfy part or all of the electrical energy use of the building. On the other hand, when the cogeneration processes were operated to meet the electrical load, i.e. electrical load following (ELF), they co-generated heat, which could be used to satisfy part or all the thermal energy use of the building. Figure 2 and Figure 3 show illustrations of thermal and electric load following scenarios, respectively. The electrical and thermal energy production from the cogeneration processes corresponded to their respective electrical and thermal efficiencies. The electrical and thermal production from the energy systems is detailed in Chapter 3.

The cooling demand of the building was satisfied using an absorption or electric chiller while the heating demand was satisfied using a gas boiler. In the baseline scenarios, the absorption chiller was run by heat from the gas boiler and the electric chiller was either run by electricity generated from the U.S. average electric generation mix or natural gas-fired combined cycle, depending on the scenario. For cogeneration system in thermal load following scenarios, the absorption chillers (run by heat from the cogeneration processes) were used to meet the cooling load.

On the other hand, for cogeneration systems in electric load following scenarios, three different systems were examined for cooling: electric chiller, absorption chiller, and a combination of electric and absorption chillers. The first option the cogeneration processes meet the electric load of the building, including cooling by electric chillers (EC). In the second option, the cogeneration processes were operated to meet the electric load of the building (mainly equipment and lighting) and the co-generated thermal energy from the cogeneration processes drives absorption chillers (AC) to meet the cooling load. Operating the cogeneration processes to produce sufficient heat to run the absorption chillers satisfied any unmet cooling load. In the third option, the cogeneration processes were operated similar to the second option except that the cooling load was satisfied by a combination of absorption and electric chillers. Operating the cogeneration processes to run a combination of absorption and electric chillers (AC/EC) satisfied any unmet cooling load. In all options, if the thermal energy produced from the cogeneration processes was less than the thermal demand of the building, i.e. space and water heating energy use, gas boilers were used to meet the thermal energy use of the building.

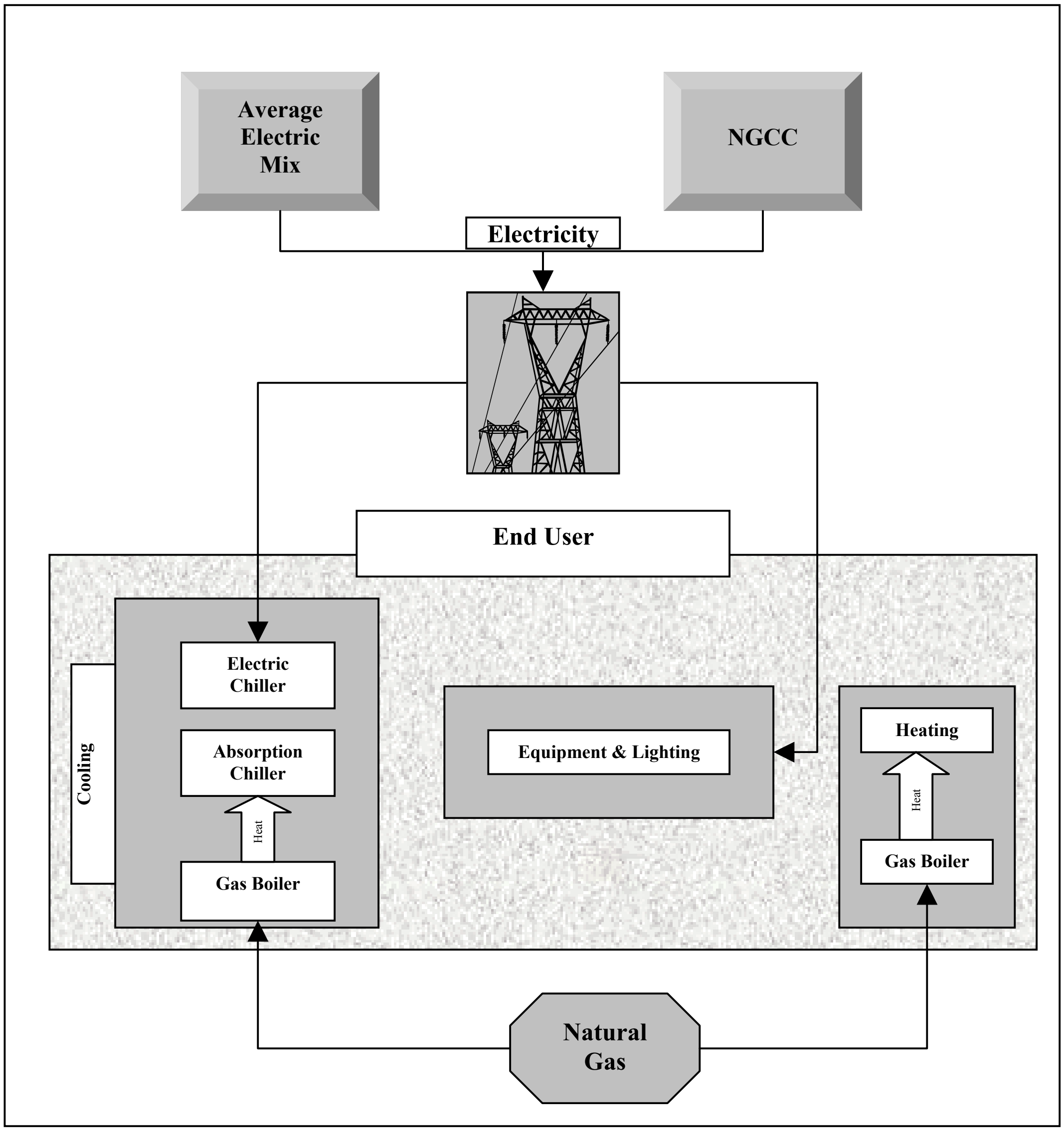


Figure 1: Illustration of Baseline Scenarios.

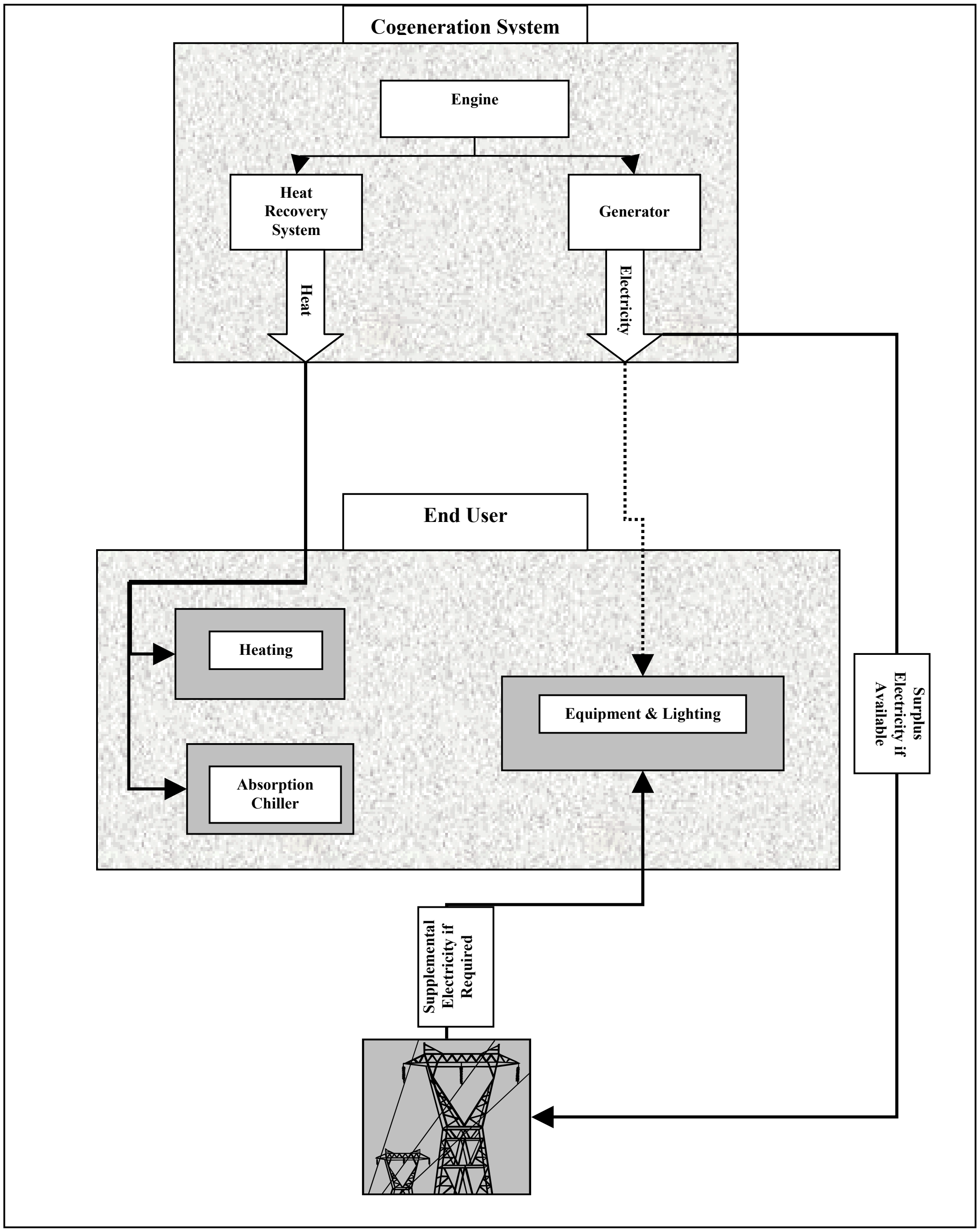


Figure 2: Illustration of Thermal Load Following Scenarios.

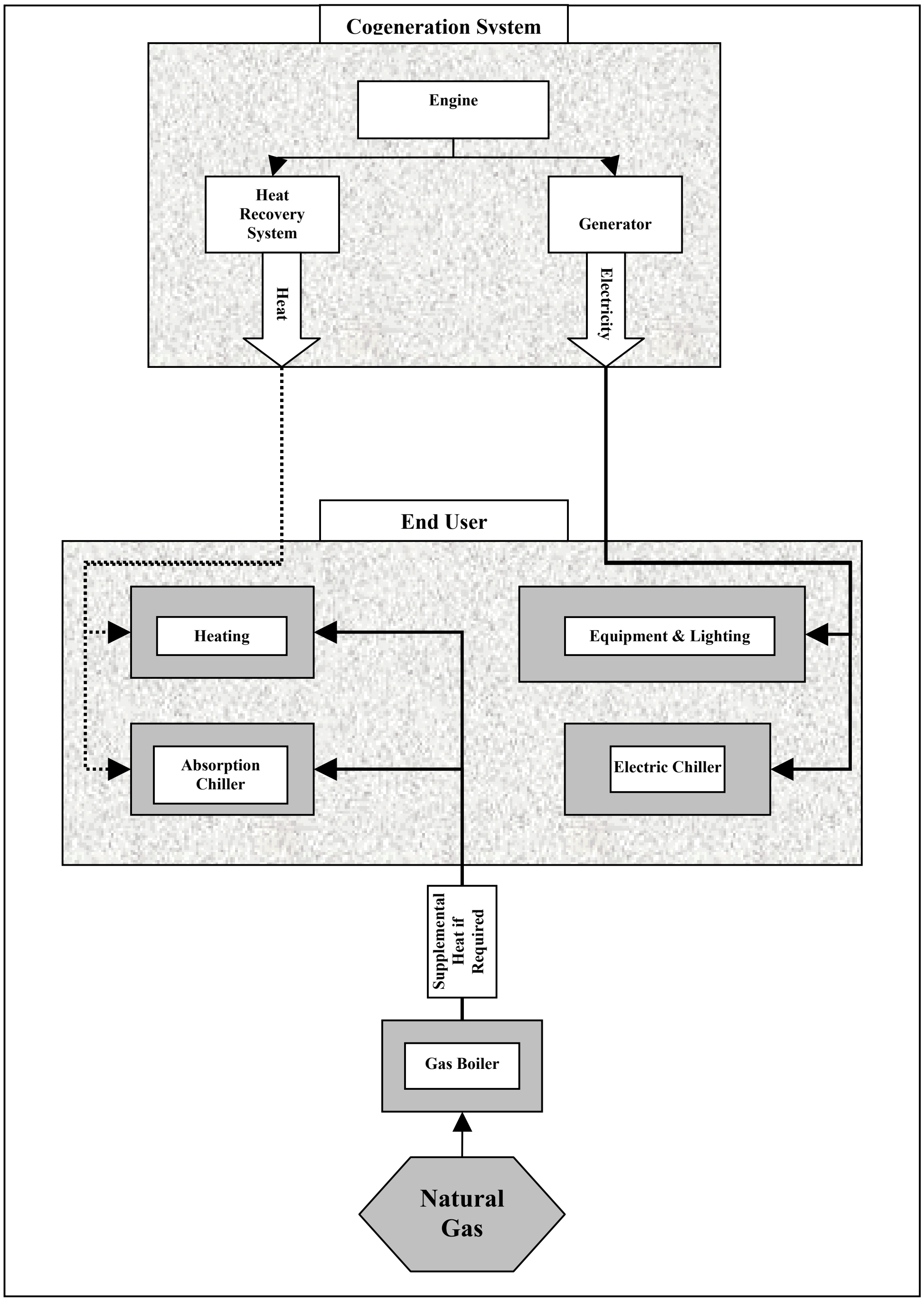


Figure 3: Illustration of Electrical Load Following Scenarios.

A detailed description of the LCA model, the building characteristics, the energy systems used for energy production, and the scenarios are given in Chapter 2.

The environmental impact indicators used to quantify the potential contribution from the products' inventory flow in this study were:

(a) Primary Energy Consumption: a measure of the total amount of primary energy resources needed to deliver energy and is also a quantitative measure of resource depletion,

(b) Global warming potential (GWP): is mass based equivalent of the radiative forcing of green house gases, expressed in CO_2 equivalents,

(c) Tropospheric Ozone Precursor Potential (TOPP): is mass based expression of the ozone formation rate from precursors, expressed in ozone precursor equivalents, and

(d) Acidification potential (AP): is the result of aggregating acidifying air emissions, expressed in SO_2 equivalents.

The results from the three scenarios (baseline, thermal, and electrical) were analyzed on an hourly, daily, and annual basis. Three months were used for hourly and daily analysis: January, representing a heating month, and May and August representing cooling months. The results were also normalized to compare the primary energy consumption and emissions from the various processes in the scenarios. Detailed description of the environmental analysis is given in Chapters 4 and 5.

1.3 Literature Review

A literature search was conducted before starting the project to determine the main emissions from the prime movers studied. The Environmental Protection Agency (EPA) AP-42 was used to obtain the emission factors for natural gas combustion in the gas boiler, gas turbines, and the internal combustion engines. The emissions factors for theses processes are given in Appendix B. Carbon dioxide emission factors for the SOFC were obtained from the Arthur D. Little Report, also given in Appendix B (Little, 2000).

Also, a literature review was conducted to assess the work done in life cycle assessment and environmental impact assessment of CHP technologies. Most of the studies and demonstration projects preformed in the application of CHP technologies, such as Brandon, 2000; Curtiss, 2000; Ellis and Gunes, 2002; ESCAP, 1999; Jones, 1999; Jalazadeh-Azar, Slayzak, and Ryan, 2002;[4] Yodovard et al., 2001, focused on evaluating the economic aspects of using these technologies and optimizing theses systems to minimize costs without addressing the life cycle environmental impact of using these technologies.

LCA Studies

A life cycle assessment was performed Spath and Mann to quantify and analyze the environmental aspects of producing electricity from a NGCC power generation system, including all necessary upstream operations (Spath and Mann, 2000). A software program was used to model (design and analyze) the NGCC and another software program was used to track the material and energy flows between the process blocks within the system. Two Siemens Westinghouse gas turbines, three pressure heat recovery steam generators, and a condensing steam turbine are used to build the model for the NGCC (Spath and Mann, 2000).

For GWP, CO_2 is found to be responsible for 88% of the system GWP and CH_4 for 11.6%. Nearly all of the methane emissions result from natural gas losses during extraction and distribution while most of the carbon dioxide emissions result from the power plant operation. It

[4] Jalazadeh-Azar, Slayzak, and Ryan, 2002, also included primary energy consumption analysis in their study.

is found that power plant operating emissions (principally CO_2) are responsible for 75% of the system GWP and natural gas production and distribution is responsible for 25%. From sensitivity analysis performed for the LCA, it is found that increasing the power plant efficiency (meaning that more electricity is produced per unit of fossil fuel) and reduction in natural gas losses will reduce the environmental impact of the system. Reducing natural gas losses during production and distribution will lower the GWP and decrease energy loss. In addition, a comparison between environmental impacts from using coal versus natural gas in generating electricity was included in the article (the LCA of coal-fired power plants was conducted by Spath and Mann in 1999). Because of the differences in feedstock composition, coal plants are noted for producing more CO, SOx, NOx, and particulates, and also generate a large amount of waste per kWh of electricity produced. In addition, the lower levels of criteria air pollutants result in lower capital and operating expenses associated with meeting air quality regulations (Spath and Mann, 2000). Note that other environmental parameters are studied in the article, such as energy and resource consumption, water emissions, and solid waste. Although the authors suggested the use of natural gas to generate electricity and replace the major form of power production in the US (coal fired power plants) to increase the efficiency and reduces the environmental impact, they didn't address the issue of natural gas reserves and energy conservation and cost impact on consumers by switching to natural gas.

The environmental impacts of electric generation options (hydropower, diesel, natural gas combined cycle turbines, coal, heavy oil, biomass, nuclear, wind, and solar voltaic) from life cycle assessment studies carried out around the world are summarized in an article by Gagnon, et al. (Gagnon et al., 2002). Coal is found to have the highest greenhouse gas emission factor, with twice the emissions of natural gas combined cycle. Fuel cell, (emissions are mainly from reforming natural gas to hydrogen), is found to have higher greenhouse gas emission factors than natural gas turbines but less than coal. For acid precipitation, coal is found to have the highest emissions of SO_2 without SO_2 scrubbing but lower emissions than natural gas combined cycle and fuel cell with SO_2 scrubbing. Also, coal has the highest NOx emissions with or without SO_2 scrubbing, which is less than that from natural gas combined cycle. It was stated that natural gas can be a significant source of acid precipitation when considering the processing of fuel and NOx emissions. Other environmental parameters such as land requirements, energy payback ratio, and health issues were discussed in the article. The main findings are that hydropower and wind-power have excellent performance, nuclear energy has excellent performance when radioactive wastes and concerns about catastrophic accidents are not considered (these issues were not included in the LCA), natural gas generation is found to be better than coal or oil-fired generation, but it has high emissions relative to renewable sources, and coal is found to have the worst performance on most environmental impacts (Gagnon et al., 2002). Although the article provides a good overview of the environmental impacts from the systems examined, it has little description of the systems, such as sizes and types of processes.

A life cycle assessment study was conducted to assess the environmental impacts of four different types of energy systems delivering heat, transportation, electricity, and combined heat and electricity, for continental European energy systems (Michaelis, 1998). For the delivery of heat to domestic consumers, it is found that there is little difference in natural gas and heating oil fuel in terms of greenhouse gas emissions and eutrophication but heating oil systems have higher acidification potential and resource depletion. It is also found that the environmental impacts of the supply of natural gas to the user are small relative to those from its combustion in boilers. For supplying heating oil, although the greenhouse gas emissions are found to be small, the impacts due to extraction, processing and distribution are significant. The supply of electricity considers: oil, coal, natural gas, nuclear, and solar-derived electricity. Of the fossil fuel electricity production systems, natural gas is found to produce the lowest acidification and eutrophication impact, coal is found to produce the largest greenhouse gas emissions, and oil is found to have the largest impact on resource depletion. Photovoltaic electricity is found to have the lowest environmental impact when compared to the other systems except in acidification where it exceeds that of natural gas electricity. Nuclear power has the lowest environmental impact of all systems as its main emissions are radioactive emissions. In addition, it is found that the supply of electricity to consumers using natural gas as fuel have the lowest impact if a combined heat and power plant is used; however, when gas is used to produce electricity, which is transformed to heat and electricity at the point of use, it has the highest environmental impact when compared to the other systems (Michaelis, 1998). The article provides detailed information on the LCA approach used as well as descriptions of the energy producing and delivering systems.

Carbon dioxide reduction using technical solutions in three hypothetical plants for power production has been studied in a project by Lombardi (Lombardi, 2002). The three possibilities considered in the project are: natural gas fired combined cycle with partial recirculation of the flue gas and chemical absorption of CO_2 from exhausts; an integrated coal gasification combined cycle with CO_2 chemical absorption from the syngas; and an innovative methane fueled cycle where, due to combustion of pure oxygen, CO_2 is the cycle working fluid. While in the first two plants, CO_2 is removed by chemical absorption, the integrated coal methane fueled cycle has no emission at the stack during the operation phase because CO_2 is extracted in almost pure form in the liquid phase due to high pressure operation. A life cycle assessment is used as comparison criteria for the options studied, considering the entire life time of the plants: construction, operation, and dismantling. The results showed that the methane fueled cycle has no CO_2 emissions, followed by the natural gas-fired combined cycle which has about half the amount of CO_2 emissions per MWh as the integrated coal gasification combined cycle. It is also concluded that since most of the emissions are found to result from the operation phase, attention must be focused on this phase since construction and maintenance phases contribute negligibly to the emissions. It is also stated that the best solution is to develop machinery to operate the methane fueled cycle but the addition of CO_2 chemical absorption can supply great advantage with respect to the present state-of-art of the power generation technology (Lombardi, 2002). The paper also includes exergetic life cycle assessment, which has similar conclusions to the LCA study. A detailed description and analysis of the LCA and exergetic LCA of the natural gas fired combined cycle with partial recirculation of the flue gas and chemical absorption of CO_2 from exhausts is presented in another article (Lombardi, 2001).

CHP Studies

A medium-sized office building located in the University of Maryland is used to demonstrate the potential for CHP application in commercial buildings (Marantan, Popovic, and Radermacher, 2002). The baseline electricity characterization was performed to determine equipment operations, building operation sequences, and to detect opportunities for improvements. Natural gas is mainly used for water heating and electricity is used for space heating and cooling; both natural gas and electricity are purchased from local utilities. The study group found that improvements could be made by utilizing desiccant dehumidifiers to provide direct humidity control as part of a building's CHP system. Desiccants can be regenerated by using waste heat available from CHP power generating equipment, such as microturbines or fuel cells. They also found that high electricity consumption during heating and cooling seasons can be reduced by using available heat from power generating equipment for space heating or cooling (Marantan, Popovic, and Radermacher, 2002).

Methods used in distributed generation control in commercial buildings are summarized in an article by Curtiss in the context of the U.S. utility industry. The methods can integrate building load, generation, and grid information to produce optimal set points for the generator and HVAC system in the building served by a given generation system (Curtiss, 2000). Some of the techniques that can be used to control on-site generation that the author described in the article are:

- Threshold control: the turbine runs whenever the building electrical load is greater than a predetermined threshold,
- Buyback priority: used when the building operator wishes to produce electricity and sell any or all of the produced power back to the utility,
- Cooling/heating priority control: generators are used to meet the peak thermal load of the building with no consideration given to the value of electricity,
- Optimal control: distributed generation would be operated using an algorithm that reduces the operating cost over the lifetime of the equipment. Parameters such as building electrical and thermal energy use, water heating, space heating and cooling, as well as electricity and natural gas and utility intensives are all taken into consideration.

Several case studies that are investigated in the article showed that the optimal control technique provides an economic benefit over a simple threshold control (Curtiss, 2000).

Another study was performed to investigate different optimization techniques to operate a cogeneration energy system (Jones, 1999). The techniques studied were thermal tracking (the cogeneration system is operated to meet the hot water demand and supplement the building's electric load), electric tracking (the cogeneration system is used to satisfy the electrical needs of the facility and the supplement the heating load), and economic tracking (calculations are performed to determine the break-even point at which the electricity cost to run the co-generator becomes economically impractical). A microturbine was sized to meet the hot water demand of the athletic building used in the study and both the thermal and economic tracking are found to be the optimal operation strategies. However, although it was economical to always run the co-generator, because of safety issues (no staff to monitor the operation when the facility is closed), it is found that the thermal tracking is optimum for the facility (Jones, 1999). Although the paper contains many details of thermodynamic, economic, and probability analysis, the only environmental impact discussed is the GWP, which leaves out other environmental impacts of using this cogeneration system.

A study was done by Jalalzadeh-Azar et al. in 2002 to evaluate the application of CHP for office buildings. The study focused in evaluating the efficiency of microturbine generators on the total primary energy consumption and cost in different climates for a hypothetical office building. In one scenario, the cogeneration units are sized and operated to supply the required heat input of the thermally driven cooling (absorption cooling) and heating systems at any given time; the system relies on power supply from the electric grid because of the limited power generation from the units. In a second scenario, the CHP is sized and operated to meet the electrical energy requirement of the building; when the amount of recoverable heat from the system is insufficient for operating space and water heating systems, gas-fired devices are used to meet the demand, whereas cooling is met my electric DX system. One of the major findings is that energy consumption and costs for both scenarios are insensitive to the climates considered except for very low electric to gas cost ratios. From the analysis of the result, it is found that the second scenario has significantly higher yearly energy cost than the first scenario. It is also found that improving the microturbine efficiency has a positive impact on the overall primary energy consumption for both scenarios. It is also demonstrated that the implementation of CHP offers opportunities to reduce primary energy consumption and yearly energy cost; in addition to providing reliability in supply of electric power (Jalalzadeh-Azar, Slayzak, and Ryan 2002).

Improvement in economic performance by increasing microturbine system efficiency is demonstrated in work by Brandon, 2000. The program that has been started in collaboration with a number of Canadian gas and electric utilities to develop and field test a low-cost and reliable heat recovery system for the newly available microturbine technology showed that the system efficiency of the microturbine could be increased from 30% to 75% through the use of heat recovery, resulting in significant improvements in economic performance (Brandon, 2000).

The article contains design and fabrication information about the heat recovery system as well as recommendations for site conditions for installing the microturbine system.

A case study in a pulp and paper mill in the Philippines demonstrated the use of cogeneration system in a plant that utilizes electricity and thermal energy simultaneously (ESCAP, 1999). Three cogeneration systems alternatives were considered for the plant: steam turbine, gas turbine, and reciprocating systems. The systems were evaluated based on technical and economical performance. The energy consumption of the plant was analyzed and the cogeneration alternatives were used to match the plant's thermal requirements at one time and the electricity requirements at another (base and peak power and heat requirements for power and thermal matching are investigated). Some of the factors considered in the technical analysis are efficiency, enthalpy, and fuel consumption. The steam turbine meeting the base steam demand was found to be the most suitable cogeneration process (ESCAP, 1999). The paper also includes detailed economic analysis of the alternatives considered.

The use of waste heat from diesel cycle and gas turbine cogeneration is investigated by Yodovard et al., 2001. The potential of heat thermoelectric power generators, which convert part of a quantity of heat absorbed directly into electrical power, was analyzed using annual cost method based on stack exhaust from a cogeneration system for different operation hours, system life spans, and other cost-related elements including electricity buy back rates. The data used in the analysis was based on different manufacturing industries in Thailand. Gas turbine and diesel cycle cogeneration systems produced electricity estimated at 33% and 40% of fuel input, respectively. The useful waste heat from stack exhaust, (exhaust heat from the heat recovery boiler remaining after the heat is extracted for process steam), of cogeneration systems was estimated at 20% for gas turbine and 10% for diesel cycle. The corresponding net power generation is about 100 MWe (Yodovard et al., 2001). The paper includes a mathematical model for thermoelectric power generation.

Ellis and Gunes evaluated the application of fuel cells for CHP in residential and commercial buildings. The study focused mainly in evaluating the economic aspects of using fuel cells. The fuel cell CHP system studied included fuel cell stack (converts chemical energy in the fuel to electricity and heat), fuel processor (converts hydrocarbons to hydrogen or hydrogen and carbon monoxide), power conditioner (regulates output power), air supply subsystem (provides conditioned air to the fuel cell and fuel processor), thermal management (removes heat from the stack and transfers heat to system components and supplies external thermal loads) and water management subsystems (ensures the removal of water from the stack and that water is available for fuel processing and reactant humidification). The fuel cells discussed in the paper were a proton exchange membrane fuel cell, phosphoric acid fuel cell, molten carbonate fuel cells, and solid oxide fuel cell. The economics of general case studies for fuel cell cogeneration are presented for residential and commercial applications. It is found that CHP systems employing fuel cells can be economically attractive if the initial costs can be reduced to the range of \$1000 to \$1500/kWe (Ellis and Gunes, 2002). The article includes detailed description of the fuel cell technologies and general characteristics of fuel cell systems.

Gunes also published a thesis on the investigation of a fuel cell based total energy system (TES) for residential application (Gunes, 2001). The size and characteristics of the house studied are based on data available from the Energy Information Administration; the average lighting and domestic hot water use profiles are obtained from the literature; and the space heating and cooling loads are obtained by applying a building energy simulation program. The research focused on establishing the energy requirements for a single-family residence, modeling the performance of a fuel cell based TES in response to the energy requirements, and evaluating energy use characteristics and life cycle cost for various climatic conditions. The fuel cell system was designed to meet the light and appliances loads as well as space cooling and the thermal output was transferred to a thermal storage tank, which was used for domestic water and space heating. Domestic water and space heating loads that cannot be met thermally were supplied electrically. A numerical model of the TES was developed and energy savings and economic evaluation (life cycle cost) of the system have been analyzed in the paper. In warmer climates the system is sized for electricity requirements on the peak cooling day and in colder climates the system is sized for the peak heating day. It was found that the TES introduces 32 to 51 percent primary energy savings over conventional residential energy systems. In colder climates, more than 70% of the thermal energy generated in the fuel cell system can be used for heating, which satisfied the thermal and electric load requirements of the building. It was concluded that since the thermal energy was very effectively used by the TES, it is not likely that more complex systems (e.g. absorption cooling) can be justified based on improved utilization of thermal energy (Gunes, 2001).

A life cycle assessment study was performed by Pehnt to address the use of fuel cells and relevant fuel chains and their environmental impact (Pehnt, 2001). The author used two examples to demonstrate the use of fuel cells and their environmental impacts: SOFC in industrial cogeneration and centralized electricity production (used natural gas as fuel), and FC used in passenger car. The author used GWP and acidification as examples of environmental impact. For the stationary application of the SOFC, fuel supply, including exploration, extraction, processing, and transport; manufacturing and recycling of SOFC; operation; and recycling and disposal are all elements that were considered in the life cycle assessment. For GWP, a SOFC in cogeneration is found to be 12% more efficient than a future gas turbine, and 47% more efficient than a future German electricity generation mix. It is also found that SOFC produces 70% less acidification than a low NOx gas turbine and 30% less than a modern natural gas combined cycle. The acidification emission from SOFC stems from the energy chain and the production of the system while for gas turbines 50% of total acidification comes from direct NOx emissions. The results also showed that although global warming potential of SOFC with CHP is lower than SOFC only, the global warming potential of SOFC (CHP), SOFC, gas turbine (CHP), and NGCC are all comparable and are lower than that of electricity (average) (Pehnt, 2001).

A detailed technical description of power generation by combined fuel cell and gas turbine systems is given by Archer, 1996. The author explains that to obtain the highest possible efficiency in electrical generation, both the thermal energy in the heat and the unburned fuel reject from the cell (SOFC and MCFC) must be recovered and converted to additional electrical energy. This can be accomplished by a heat engine cycle making use of a gas turbine operating in regenerative Brayton or combined Brayton-Rankine cycle or a steam turbine operating in a Rankine cycle. For all three of the heat recovery arrangements, which make use of the high operation temperature of the fuel cells, the calculated overall efficiencies are found to be greater than 70% (Archer, 1996). The paper includes a description of the mentioned cycles and a discussion of technical elements associated with the different modes of operation of the fuel cells.

Although on-site cogeneration presents a high potential for the commercial sector, the literature reviewed has few examples that address the benefits that could be gained with the application of these technologies. In addition, the studies reviewed lack a comprehensive assessment of the environmental impacts resulting from the use of cogeneration systems in particular, and energy generation systems in general. Moreover, most of the studies used annual data of energy use as a basis for sizing the cogeneration systems, whereas, daily and hourly trends could provide more insight on how these systems could be operated more efficiently. Also, most of the life cycle assessment studies that addressed environmental impact issues are done on systems that are used in large energy generation plants, while studies that addressed some of the cogeneration processes only looked at certain aspects of LCA such as costs and energy use. Hence, a more comprehensive study is required to encompass all the inputs and outputs of processes used in energy generation systems, and address environmental impacts resulting from these systems in use. In addition, since the cogeneration systems could be operated in different modes and their electrical and thermal energy could be used to run various equipment for heating, cooling, etc., a model will help in comparing some of the operational strategies that could be used with the various cogeneration systems.

2.0 STUDY DESCRIPTION

This chapter includes the following sections:

Section 2.1: Life Cycle Assessment Study

The section addresses the life cycle assessment study, which covers the goal and scope of the study, inventory analysis, study boundaries, assumptions and limitations, and environmental impact assessment.

Section 2.2: Systems for Energy Production

The section is sub-divided into the following section:

Section 2.2.1: Conventional Electric Generation Systems

The section provides description of the systems used for conventional energy generation, which includes: the conventional U.S. average electric generation mix, the high efficiency natural gas combined cycle process (NGCC).

Section 2.2.2: Cooling Systems

The section provides description of the two cooling systems examined in the study: electric chillers and absorption chillers.

Section 2.2.3: Heating System

The section provides description of a gas boiler model used to provide heating in the study.

Section 2.2.4: Cogeneration Systems

The section provides description of the three cogeneration systems investigated in the study: solid oxide fuel cell (SOFC), microturbine, and internal combustion engine (ICE).

Section 2.3: Scenario Descriptions

The section outlines a description of the operational strategies investigated in the study described in the following sub-sections:

Section 2.3.1: Baseline

Section 2.3.2: Thermal load following (TLF)

Section 2.3.3: Electric load following (ELF)

Section 2.4: Calculation Methodology

The section covers the basic calculation methodology used in the study.

2.1 Life Cycle Assessment Study

The study followed the LCA framework described in the international standards ISO 14040. According to the international standards, the LCA phases were the "goal and scope" definition, the "inventory analysis," the "impact assessment," and "interpretation." LCA studies the environmental aspects and potential impacts throughout a product's life (i.e., cradle-to-grave) from the raw material acquisition through production, use and disposal (ANSI, 1997). In addition, it considered the materials needed for construction, transportation, and auxiliary materials and energy.

Some of the limitation present in LCA studies are (ANSI, 1997):

- The nature of choices and assumptions made in LCA, such as system boundaries, may be subjective,
- Models used for inventory analysis or to assess environmental impacts are limited by their assumptions, and may nor be available for potential impacts or applications,
- Results of LCA studies focused on global and regional issues may not be appropriate for local applications,
- The accuracy of LCA studies may not be limited by accessibility or availability of relevant data, or data quality, i.e., gaps, aggregation, average, site-specific etc., and
- The lack of spatial and temporal dimensions in the inventory data used for impact assessment introduces uncertainty in impact results. This uncertainty varies with the spatial and temporal characteristics of each impact category.

Goal and Scope of the Study

The goal of this study is to evaluate natural gas-fired cogeneration technologies for heating, cooling and electrical energy generation in commercial buildings and compare these systems based on their primary energy consumption and emissions. A 100,000 square feet hypothetical commercial office building was used for the case study.

Commercial buildings in the U.S. are one of the largest sectors that purchase electricity. On average the commercial and residential sectors pay significantly more for electricity than the industrial sector, mainly because some of the industrial sectors generate their own electricity (Little, 2000). In commercial buildings, natural gas is recognized as the principal fuel for space and water heating, with electricity generated off-site used for cooling loads, lighting needs, and office equipments etc. Using natural gas-fired cogeneration systems will allow commercial buildings not only to generate their own electricity but also to use energy efficiently because these technologies make use of the otherwise wasted thermal energy and utilize it for a variety of purposes, such as space and water heating as well as cooling.

In addition to energy efficiency, natural gas-fired cogeneration systems emit fewer pollutants than conventional coal- and oil-fired systems. For one reason, natural gas has a lower sulfur, nitrogen, and carbon content than coal resulting in lower emissions of substances that result in acidification, ground level ozone formation, and global warming. Also, with the efficient use of energy, less primary energy is consumed.

Using LCA as a tool, which considers all elements associated with materials and fuels used in the processes studied, such as exploration, processing, transportation, transmission, distribution and use, will provide a common ground for understanding and comparing energy systems used for electrical and thermal generation and their impact on the environment. Understating these systems, performance is a key not only for consumers but also for decision makers in energy use policies and environmental regulation.

The scope of this study covered the following:

- Geography and Climate

  The location chosen for the hypothetical building was Missouri (Columbia), which is characteristic of Midwest climate.

- Technologies

  Three cogeneration technologies were examined for providing space and water heating, cooling, and electric energy for equipment and lighting:

  1. Solid oxide fuel cell (SOFC)
  2. Microturbine
  3. Internal combustion engine (ICE)

  The following systems were considered for electric energy supply:

  1. U.S. average electric generation mix
  2. Natural gas combined cycle power generation (NGCC)
  3. On-site cogeneration

  The following systems were considered for thermal energy supply:

  1. Natural gas-fired boilers
  2. On-site cogeneration

  The following systems were considered for cooling energy supply:

  1. Electric chillers
  2. Absorption chillers

- Operational Strategies

  The following strategies were examined for operation of energy systems:

  1. Baseline: U.S. average electric generation mix and NGCC supplied the electric energy use of the building with electricity including cooling.
  2. Thermal load following (TLF): on-site cogeneration systems were operated to meet the thermal load of the building and the co-generated electricity was used to meet part or all of the electric energy use of the building.
  3. Electric load of the building (ELF): on-site cogeneration systems were operated to meet the electrical load of the building and the co-generated heat was used to meet part or all of the thermal energy use of the building.

Inventory Analysis

The life cycle inventory includes unit processes with inputs, such as raw materials, fuels, auxiliary materials and energies, and outputs, such as, products, emissions, water and solid wastes effluents, and electrical and thermal energies. These processes were linked to one another by flow of products (transportation, distribution lines, water/waste effluents, energy etc.). A literature search was performed to assess the current and emerging cogeneration technologies. Data from literature and commercially available systems, such as boilers, chillers, and cogeneration processes are used to define the modeled unit processes' characteristics, such as energy efficiencies, sizes, weights, compositions, emissions etc. Also, data from previous studies are used for other processes and emissions. A detailed description of the systems considered for energy production, assumptions, as well as the calculations performed to quantify the materials and fuel use, primary energy consumption, and emissions follows in this Chapter. A list of the processes used in the model is given in Appendix A.

The LCA software, GEMIS, (Global Emission Model for Integrated Systems), was used to develop and analyze the different scenarios as well as to provide some of the basic data on energy carriers (process chains and fuel data). A *scenario* in GEMIS is composed of demands, such as electricity, heating, and cooling, which are supplied by *processes*, such as power plant, boiler, chiller etc. A process in GEMIS is an activity which converts, transports, or produces a *product*, such as an extractor which converts a resource into primary energy or material. Products in GEMIS, on the other hand, depending on the process, could be fuels, emissions, resources, or residues and wastes.

The GEMIS database contains information on:

- fossil fuels (hard coal, lignite, natural gas, oil), renewable, nuclear, biomass (residuals, wood etc) and hydrogen (including fuel composition, and upstream data),
- processes for electricity and heat (various power plants, co-generators, fuel cells, etc.),
- materials: raw and base materials, and especially those for construction, and auxiliaries (including upstream processes), and

- transport: airplanes, bicycles, buses, cars, pipelines, ships, trains, trucks (for diesel, gasoline, electricity, and bio-fuels).

For each process in the model, the following factors were defined:

- efficiency, power, capacity factor, and lifetime,
- direct air pollutants (SO_2, NO_x, halogens, particulates, CO, NMVOC),
- greenhouse-gas emissions (CO_2, CH_4, N_2O),
- solid wastes (ashes, overburden, FGD residuals, process wastes),
- liquid pollutants (AOX, BOD_5, COD, N, P, inorganic salts), and
- land use.

Figure 4 represents a basic energy flow in GEMIS and Figure 5 shows the basic environmental impact factors considered in the model.

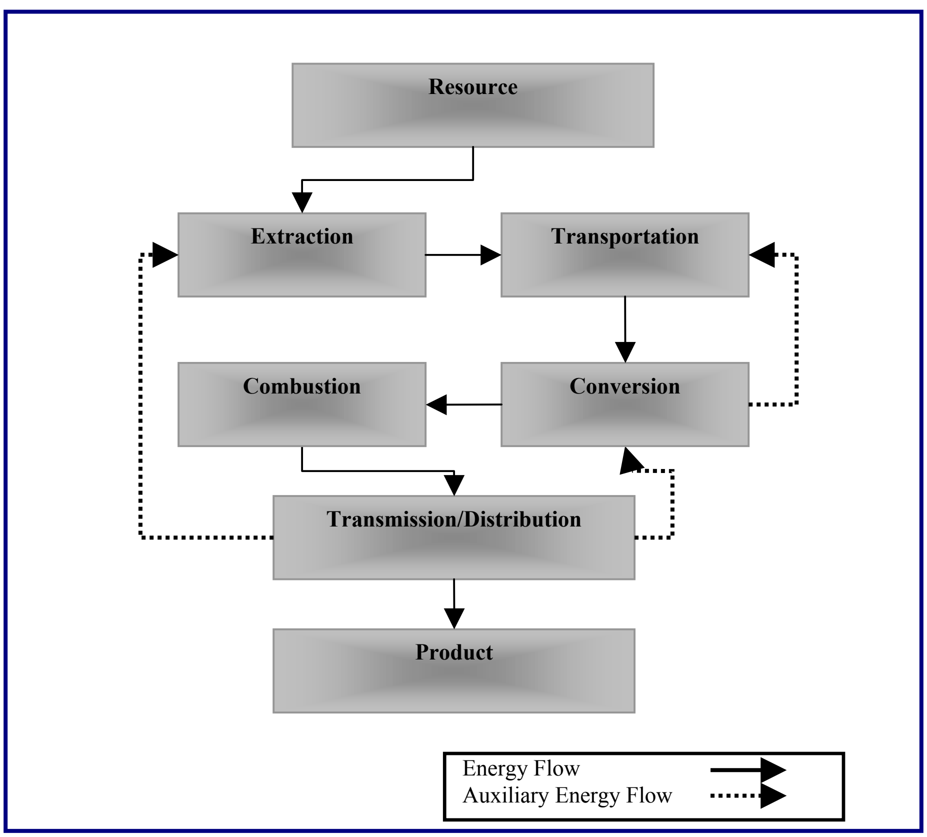


Figure 4: Energy Flow in the Model.

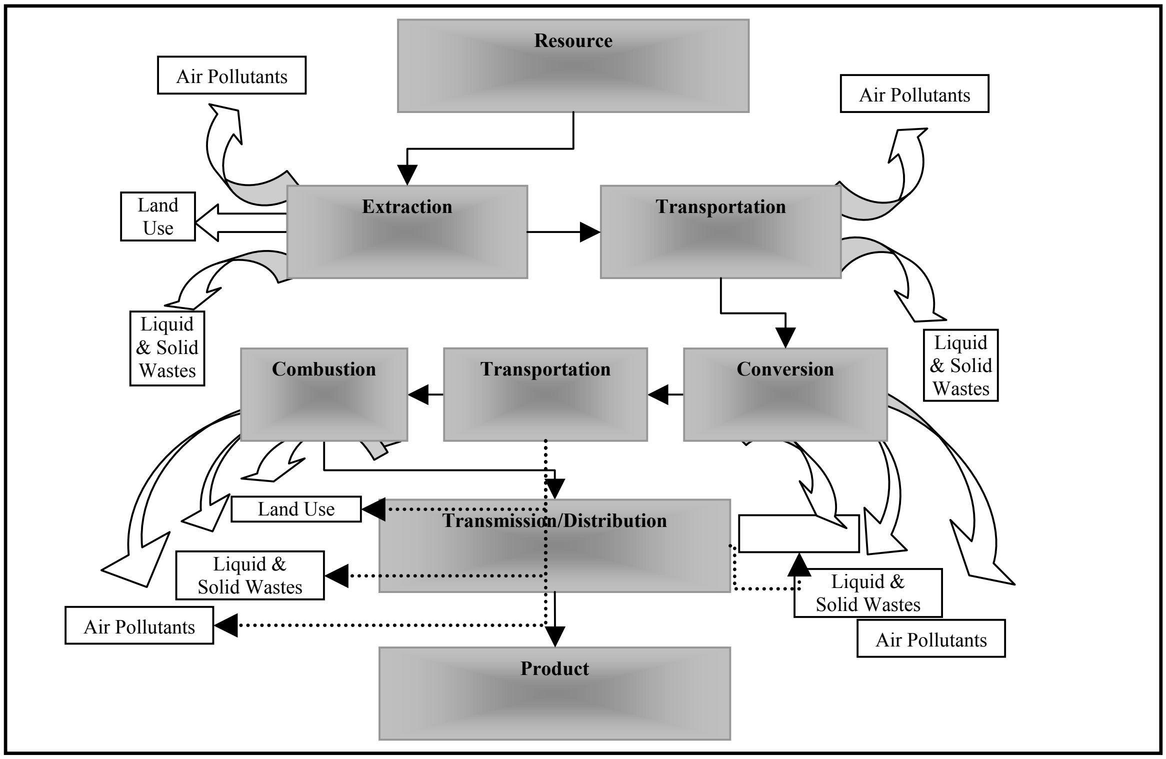


Figure 5: Emissions, Wastes, and Land Use Flow in the Model.

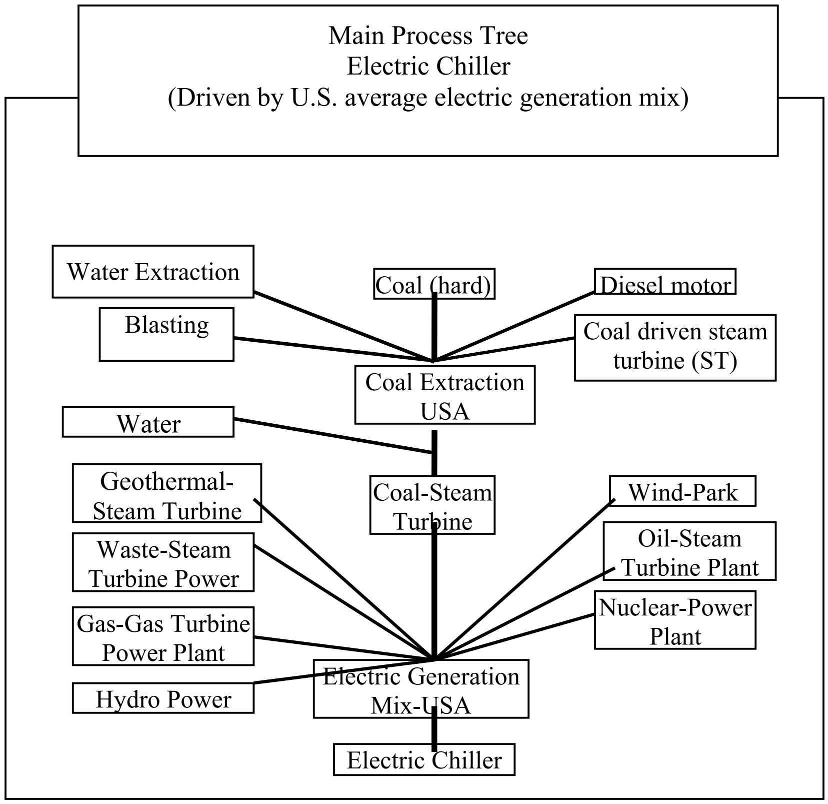
In addition to having an extensive database on the technical, environmental, and cost implications of various technologies, GEMIS allows the user to add data, such as products, create new processes, and model systems using scenarios. Once scenarios were created, GEMIS can quantify the energy use and emissions from various systems. An illustration of a scenario and a process tree is given in the following example where chiller, gas boiler, and energy systems are used to construct a scenario:

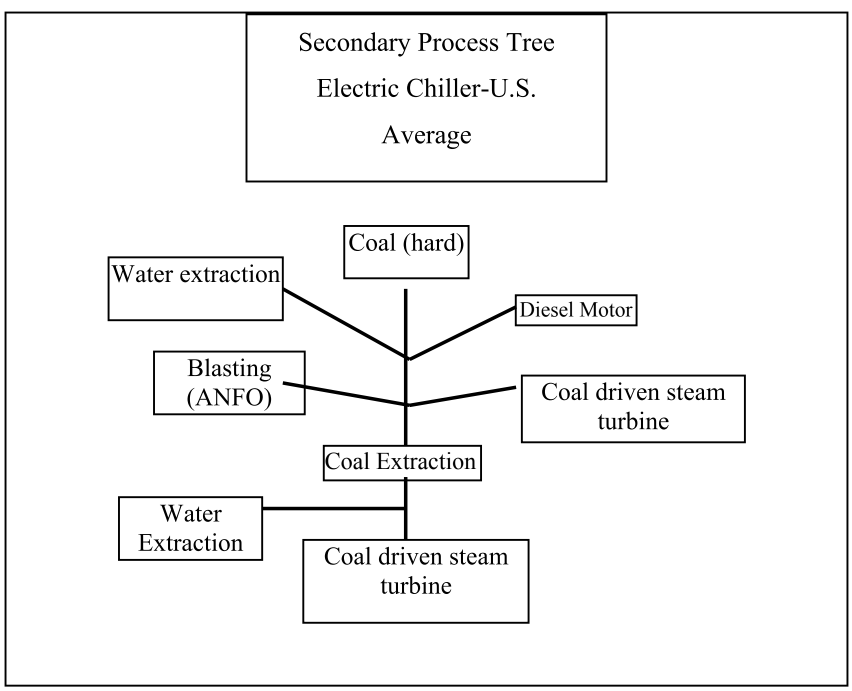
In a typical day in a month, a solid oxide fuel cell, a microturbine, a 143-kW ICE, a 3-MW ICE, U.S. average electric generation mix, and a natural gas combined cycle power plant constitute the six options in a scenario to meet the electric, heating, and cooling energy use of the building. Each of these options (using one of the above processes) was operated to meet the electric energy usage (equipment and light), a gas *boiler to meet the heating energy usage if required, and a chiller to meet the cooling energy usage if required.*

Each process was linked to other processes that make a process chain which encompass all upstream processes and products. The first process tree show the processes linked to the electric chiller that is used to satisfy the cooling energy usage of the building when a U.S. average electric generation power plant is in use. The second process tree shows one branching from the first process tree that outlines the processes associated with the process "coal-ST-USA".

(In the case of hourly energy usage, the options in the scenario were expanded to encompass the energy usage in each hour of the day, making up to 24 options).

The main process trees for the different processes used in the model are given in Appendix J.


Main Process Tree
Electric Chiller
(Driven by U.S. average electric generation mix)
Water Extraction
Coal (hard)
Diesel motor
Blasting
Coal driven steam turbine (ST)
Coal Extraction USA
Water
Geothermal-Steam Turbine
Coal-Steam Turbine
Wind-Park
Waste-Steam Turbine Power
Oil-Steam Turbine Plant
Gas-Gas Turbine Power Plant
Nuclear-Power Plant
Electric Generation Mix-USA
Hydro Power
Electric Chiller


Secondary Process Tree
Electric Chiller-U.S.
Average
Coal (hard)
Water extraction
Diesel Motor
Blasting (ANFO)
Coal driven steam turbine
Coal Extraction
Water Extraction
Coal driven steam turbine

Study Boundaries

The study is limited by the following:

- locations and climates investigated,
- building characteristics specified,
- technology specifications considered, and operational strategies examined.

Assumptions and Limitations

Assumptions made were:

- Thermal and electric conversion efficiencies of the cogeneration systems were achievable.
- Cogeneration systems were capable of following a specific thermal or electrical load of the building.
- The thermal and electric energy produced from the cogeneration processes was of utilizable quality.
- No heat or electric loses from the cogeneration processes were considered other than those captured by the conversion efficiencies.
- No credit was taken for any electrical energy generated above the demand. For instance, SOFC co-generated large quantities of electric energy when following the thermal load of the building, which could be exported to the grid, stored for future use, or used for other purposes. However, none of these options were considered in the study. Considering such option, will change the current results in this study.
- Some of the data used in the model were average data, such as U.S. average electric generation mix, which was not characteristic of a specific location but average electric energy generation in the U.S.

Some of the limitations of this study are:

- The current study was a hypothetical case which might not apply to real world scenario. In addition, the typical days in the three months analyzed (January, May, and August) represented a single occurrence and that might not be the case in real circumstances, which might include variable loads or different energy consumption patterns. This was particularly significant if considering costs associated with energy use.

- Environmental impact indicators used in this study were not representative of comprehensive environmental impact analysis but represent a class of widely used environmental parameters, which could be used for comparative analysis with previous and future studies. A comprehensive environmental impact analysis, including economic impacts, would be more valuable if the study was done on an actual setting, however, because the current study was done on a hypothetical building, the results could provide a general understanding of the performance of energy systems in buildings and ways to minimize the environmental impacts of their use. Some of the principal environmental impact indicators not addressed in this study are economic impacts, human toxicity, ecological toxicity, particulates formation, indoor air quality.
- Economic implications are not considered in the analysis. Cost analysis was not performed at this stage of the study, which is a key determinant in real world application of cogeneration systems. Furthermore, life cycle cost analysis is not only important for assessing the practicality of a system from an owner's point view but also is important in determining the economic impacts of using a different source of energy on society. For instance, coal is a major source of income for some communities in the U.S., removing or replacing such a resource would have devastating effects on the quality of lives of these communities in particular, and on the national economy in general.

Impact Assessment

The impact assessment step of the LCA evaluates the significances of potential environmental impacts using the results of the life cycle inventory analysis. The environmental impact indicators chosen to quantify the potential contribution of the products' inventory flow were:

(a) Primary Energy Consumption,

(b) Global Warming Potential (GWP),

(c) Tropospheric Ozone Precursor Potential (TOPP), and

(d) Acidification Potential (AP).

Primary energy use is a quantitative measure of the total amount of primary energy resources needed to deliver energy. It quantifies resource depletion. Resources are products that can be converted to energy carriers e.g. oil and coal from which fuels can be derived, wind, hydro-power etc. This impact addresses only the depletion effect of resource extraction, i.e. the upper end of the process chains, and not impacts resulting from extraction processes, such as emissions. The impact of primary energy use determines the availability of natural resources, which translates to issues such as efficiency, conservation, sustainable use, etc.

Global warming potential (GWP) is the mass-based equivalent of the *radiative forcing*[5] of green house gases (GHG), based on the specific forcing of CO_2. It is expressed in CO_2 equivalents (Refer to Table 2). Because GHG, such as methane and carbon dioxide, have different atmospheric residence times, the GWP is determined as an integral over a period of time; usually, GWP data refer to a time horizon of 100 years.

To calculate the CO_2 equivalents of greenhouse gases (GHG), mass-based relative global warming potentials (GWP) are used which specify for each GHG the equivalent amount of CO_2 having the same radiative forcing. The CO_2 equivalents of all GHG are calculated as follows:

$$GWP_{equi} = \sum (e_i * GWP_i)$$

---

[5] "Radiative forcing" is a term used to describe the reduction in infrared radiation penetrating outward through the atmosphere per unit increase in the level of gas in the atmosphere, the radiative force of methane is about 25 times that of CO_2 (Manahan, 1994).

where,

e_i = mass of GHG (i) in kg, and

GWP_i = global warming potential of emission (i), in [kg/kg]

GHG, as well as water vapor, produce a “greenhouse effect” by allowing incoming solar energy to penetrate the Earth’s surface while reabsorbing infrared radiation emanating from it. GHG absorb infrared radiation by which Earth loses heat. The levels of the GHG have increased markedly since 1850 as nations have become industrialized and as forest lands and grasslands have been converted to agriculture. Although trends in levels of these gases are well known, their effects on global temperature and climate are much less certain. Most computer models predict global warming of 1.5-5 °C, such warming would have profound effects on rainfall, plant growth, and sea levels, which might rise as much as 0.5-1.5 meters (Manahan, 1994).

Tropospheric ozone precursor potential (TOPP) is the mass-based equivalent of the ozone formation rate from precursors, measured in ozone precursor equivalents (Refer to Table 2). The TOPP represents the potential formation of near-ground (tropospheric) ozone which can cause summer photochemical smog.

The tropospheric ozone precursor potential equivalents which express the ozone formation rate potential (TOPP) is calculated as follows:

$$TOPP_{eq} = \sum (e_i * TOPP_i)$$

where,

e_i = mass of emission (i) in kg, and

$TOPP_i$ = tropospheric ozone precursor potential of emission (i), in [kg/kg]

Photochemical smog is a major air pollution phenomenon that occurs in urban areas where the combination of pollution-forming emissions and appropriate atmospheric conditions are conductive to its formation. In order for high levels of smog to form, relatively stagnant air must be subjected to sunlight under low humidity conditions in the presence of pollutant nitrogen oxides and hydrocarbons. Although not a great threat to the global atmosphere, smog does pose significant hazards to living things and materials in local urban areas. Ozone, which serves an essential protective function in the stratosphere, is the major cause in the tropospheric smog. Surface ozone levels are used as a measure of smog. Ozone phototoxicity raises particular concern in respect to trees and crops, in addition, ozone is responsible for most of the respiratory system distress (breathing is impaired at ozone levels at about 0.1 ppm) and eye irritation resulting from human exposure to smog (Manahan, 1994).

Acidification potential (AP) is the result of aggregating acid air emissions, expressed in SO_2 equivalents (Refer to Table 2).

The SO_2 equivalents express the acidification potential (AP) and are calculated from the molecular weights and the proton binding potential of the respective emissions (by definition AP = 1 for SO_2). AP_{eq} is determined as follows:

$$AP_{eq} = \sum(e_i * AP_i)$$

where,

e_i = mass of emission (i) in kg, and

AP_i = acidification potential of emission (i), in [kg/kg]

Acid air emissions, such as SO_2 and NOx, deposited in solution form is referred to as acid precipitation and deposition in dry gas and compounds as dry deposition. SO_2 contributes more to the acidity of precipitation than does CO_2 present at higher levels in the atmosphere mainly because it is significantly more soluble in water than CO_2. Although acid rain can originate from the direct emission of strong acids, most of it is a secondary air pollutant produced by the atmospheric oxidation of acid-forming gases. Such chemical reactions play a dominant role in determining the nature, transport, and fate of acid precipitation. Acid rain spreads out over several hundred to several thousand kilometers; this classifies it as a *regional* air pollution problem compared to *local* air pollution problem, smog, and *global* one, such as greenhouse gases. Emissions from industrial operations and fossil fuel combustion are the major sources of acid-forming gases. Some of the impacts of acid rain are: direct phytotoxicity to plants from excessive acid concentrations, destruction of sensitive forests, respiratory effects on humans and animals, acidification of lake water with toxic effects to lake flora and fauna, and corrosion to exposed structures, electrical relays, equipment, and ornamental materials especially those made of limestone (Manahan, 1994).

Table 2: Emission Equivalents for CO_2 Equivalents (IPCC, 1996), TOPP Equivalents (EEA, 2000), and SO_2 Equivalents (EEA, 2000).

Emission Equivalents	CO_2	CH_4	N_2O	NOx	NM-VOC	CO	SO_2	HCL
CO_2 equivalents[6]	1	21	316	-	-	-	-	-
TOPP equivalents	-	0.014	-	1.22	1.0	0.11	-	-
SO_2 equivalents[7]	-	-	-	0.696	-	-	1.0	0.878

Emission factors from EPA AP-42, emissions from previous studies, and emissions from specific commercial processes were used to estimate the emissions from energy generation systems. An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e. g., kilograms of particulate emitted per mega-gram of coal burned). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (i.e., a population average) (U.S. EPA, 1996).

The general equation for emission estimation used in the EPA AP-42 is:

$$E = A \times EF \times (1 - ER/100)$$

where:

[6] Note that CO_2 equivalents consist of other pollutants, such as perfluoromehtane and perflouroethane, but are not included in the analysis due to their negligble concentrations.

[7] Note that SO_2 equivalents consist of other pollutants, such as H_2 S, NH_3, and HF but are not included in the analysis because of their negligible concentrations in the emissions.

E = emissions,

A = activity rate,

EF = emission factor, and

ER = overall emission reduction efficiency (%): ER is the product of the control device destruction or removal efficiency and the capture efficiency of the control system.

A table of the emission factors obtained from EPA AP-42 is given in Appendix B.

2.2 Systems for Energy Production

The systems described in this section are the U.S. average electric generation mix, the natural gas-fired combined cycle, the cogeneration processes, absorption and electric chillers, and a gas boiler. A summary of the systems is given in Table 3.

Table 3: Systems for Energy Production.

System	Description
Solid Oxide Fuel Cell (SOFC)	SOFC with 80% overall efficiency (47% electrical and 26-33% thermal).
Microturbine	Natural gas microturbine with 80% overall efficiency (28% electrical and 52% thermal).
3-MW ICE	Internal combustion engine with 80% overall efficiency (39% electrical and 41% thermal).
143-kW ICE	Internal combustion engine with 80% overall efficiency (29% electrical and 51% thermal).
US Average Electric Generation Mix	Electric generation mix consisting of 53% Coal, 17% Natural Gas, 17% Nuclear, 9% Hydro, 2% Oil, 2% Waste, 0.4% Geothermal, and 0.15% Wind. Average grid loss of 6.5% is assumed in the process.
Natural Gas Combined Cycle (NGCC)	500-MW NGCC with 49% electrical efficiency.
Gas Boiler	1-MW gas boiler with 88.7% thermal efficiency. Coefficient of Performance is assumed to be 1.0
Absorption Chiller	1.5-MW absorption chiller. Coefficient of performance is assumed to be 1.05
Electric Chiller	195.5-kW electric chiller. Coefficient of performance is assumed to be 4.6

2.2.1 Conventional Electric Generation Systems

US Average Power Generation Plant

An electric power system is a group of generation, transmission, distribution, communication, and other facilities that are physically connected and operated as a single unit under one control. The flow of electricity with the system is maintained and controlled by dispatch centers. It is the responsibility of the dispatch center to match the supply of electricity with the demand for it. In order to carry out its responsibilities, the dispatch center is authorized to buy and sell electricity based on system requirements. Authority for those transactions has been pre-approved under interconnection agreements signed by all the electric utilities physically interconnected or with coordination agreements among utilities that are not connected.

The U.S. bulk power system has evolved into three major networks (power grids), which also include smaller groupings or power pools. The major networks consist of extra-high-voltage connections between individual utilities designed to permit the transfer of electrical energy from one part of the network to another. These transfers are restricted, on occasion, because of a lack of contractual arrangements or because of inadequate transmission capability. The three networks are:

- Eastern Interconnected System,
- Western Interconnected System, and
- Texas Interconnected System.

Electrical power generation plants in the U.S. are a mix of coal-, gas-, waste-, and oil-fired plants, as well as nuclear, solar, and wind generation.

Assumptions made are that the electric generation mix in the US consists of: 53% Coal, 17% Natural Gas, 17% Nuclear, 9% Hydro, 2% Oil, 2% Waste, 0.4% Geothermal and 0.15% wind (International Energy Agency, 1998). Also, an average grid loss of 6.5% is assumed in the process (EIA, 2002). Figure 6 shows a chart of the electric generation mix in the U.S.

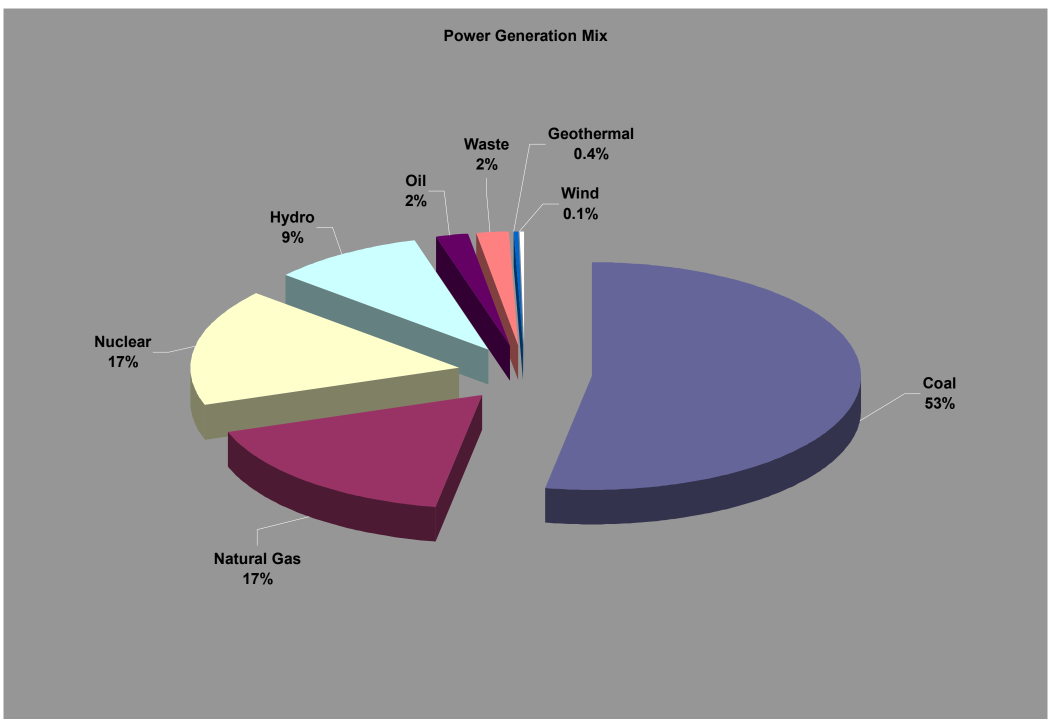


Figure 6: Electric Generation Mix in the U.S.

Natural Gas-Fired Combined Cycle Power Plant

A 500-MW natural gas-fired combined-cycle power plant (NGCC) with 49% electrical efficiency was used in the scenarios to represent best available central generation. Specifications and assumptions were acquired from a life cycle assessment study of a natural gas combined cycle power generation system (Spath and Mann, 2000).

The plant configuration consists of two gas turbines, a three pressure heat recovery steam generator, and a condensing reheat steam turbine (Spath and Mann, 2000). Natural gas is fed into a gas turbine which drives the generator. Waste heat from the turbine is captured by the heat recovery steam generator which provides steam for the steam turbine which in turn also drives a generator. In such a system, usually two thirds of the electric power is provided by the gas turbine and one third by the steam turbine (Hay, 2000). Figure 7 shows a schematic of a typical gas-fired combined cycle. Assumptions made are that the flue gas has 15% Oxygen and the stack height is 150-m. Auxiliary materials are assumed to be composed of concrete, steel, iron, and aluminum (Spath and Mann, 2000). Emissions from the NGCC are obtained from EPA's AP-42.

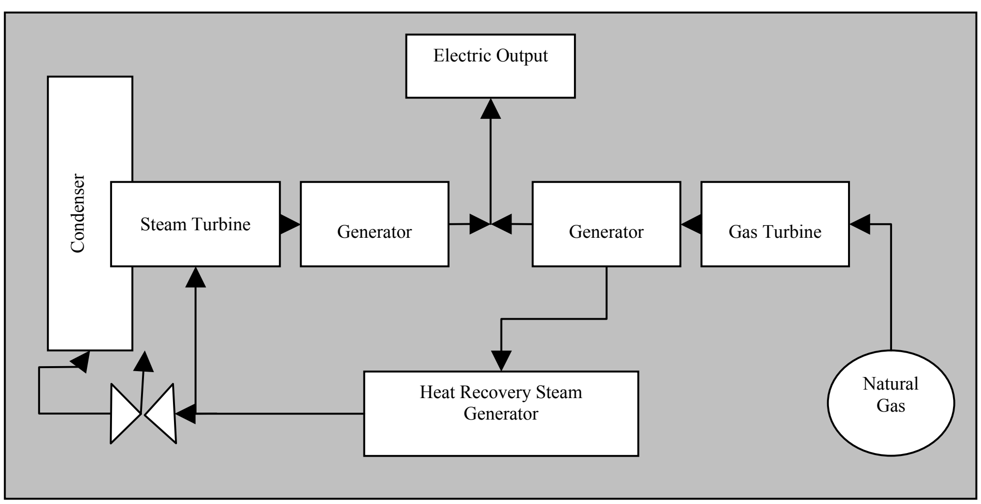


Figure 7: Schematic of a Typical Gas-Fired Combined Cycle (Hay, 1988).

2.2.2 Cooling Systems

Absorption Chiller

Operation data from a commercially available absorption chiller, (York International Corporation, 1997), was used to create the GEMIS process model for the absorption chiller. Models sizes range from 703-kW to 2372-kW; a 1537.5-kW (1.5 MW) chiller producing 5.25 MMBTU/H was chosen to supply the cooling energy usage of the building. Input heat to the absorption chiller was generated from a gas boiler.

The two stage absorption refrigeration cycle uses water as the refrigerant and lithium bromide as the absorbent. It is the strong affinity these two substances have for each other that makes the cycle work. The entire process occurs in hermetic vessels in an almost complete vacuum. Figure 8 shows the complete chilling cycle; the six steps in the diagram are detailed as follows (York International Corporation, 1997):

1. **Solution Pump/Heat Exchangers**: A dilute solution of lithium bromide and water descends from the Absorber to the Solution Pump. This flow of dilute solution is split into two streams and pumped through heat exchangers to the First-Stage Generator and to the Second-Stage Generator. There are two heat exchangers.
2. **First-Stage Generator**: A heat source heats dilute lithium bromide coming from the Solution Pump/Heat Exchangers. This produces hot refrigerant vapor which is sent to the Second-Stage Generator, leaving a concentrated solution that is returned to the Heat Exchangers.
3. **Second-Stage Generator**: The energy source for the production of refrigerant vapor in the Second-Stage Generator is the hot refrigerant vapor produced by the First-Stage Generator. (The refrigerant vapor produced in the First-Stage Generator is increased by 40%– at no additional expense of fuel. The result is much higher efficiency than in single stage systems.) The additional concentrated solution that results is returned to the Heat Exchanger. The refrigerant vapor from the First-Stage Generator condenses into liquid giving up its heat, and continues to the Condenser.

4. **Condenser**: Refrigerant from two sources – (1) liquid resulting from the condensing of vapor produced in the First-Stage Generator and (2) vapor produced by the Second-Stage Generator – enters the Condenser. As the liquid refrigerant enters the low pressure of the condenser it flashes to vapor. The two sources of refrigerant vapor combine and condense to liquid as they are cooled by the condenser water. The liquid then flows down to the Evaporator.
5. **Evaporator**: Refrigerant liquid from the Condenser passes through a metering valve and flows down to the Refrigerant Pump, where it is pumped up to the top of the Evaporator. Here the liquid is sprayed out as a fine mist over the Evaporator tubes. Due to the extreme vacuum in the Evaporator, some of the refrigerant liquid vaporizes, creating the refrigerant effect. (This vacuum is created by hydroscopic action – the strong affinity lithium bromide has for water – in the Absorber directly below.) The refrigerant effect cools the returning system chilled water in the Evaporator tubes. The refrigerant liquid/vapor picks up the heat of the returning chilled water, cooling it from 54°F to 44°F. The chilled water is then supplied back to the system.
6. **Absorber:** As the refrigerant liquid/vapor descends to the Absorber from the Evaporator, a concentrated solution coming from the Heat Exchanger is sprayed out into the flow of descending refrigerant. The hydroscopic action between lithium bromide and water-and the related changes in concentration and temperature-result in the creation of an extreme vacuum in the Evaporator directly above. The dissolving of the lithium bromide in water gives off heat, which is removed by condenser water entering from the cooling tower at 85°F and leaving for the Condenser at 92°F. The resultant dilute lithium bromide solution collects in the bottom of the Absorber, where it flows down to the Solution Pump. The chilling cycle is now completed and begins again at Step 1.

Assumptions made were that the auxiliary materials in the chiller were made from 98% steel and 2% Copper and auxiliary energy was supplied by U.S. average electric generation power plant. The coefficient of performance[8] (COP) was assumed to be 1.05.

[8] Coefficient of Performance is the heating/cooling capacity of the unit divided by its electrical input.

A sensitivity study, given in Appendix I, was used to examine the effect of different material constituents of the chiller and efficiencies on the process performance in order to determine their significance.

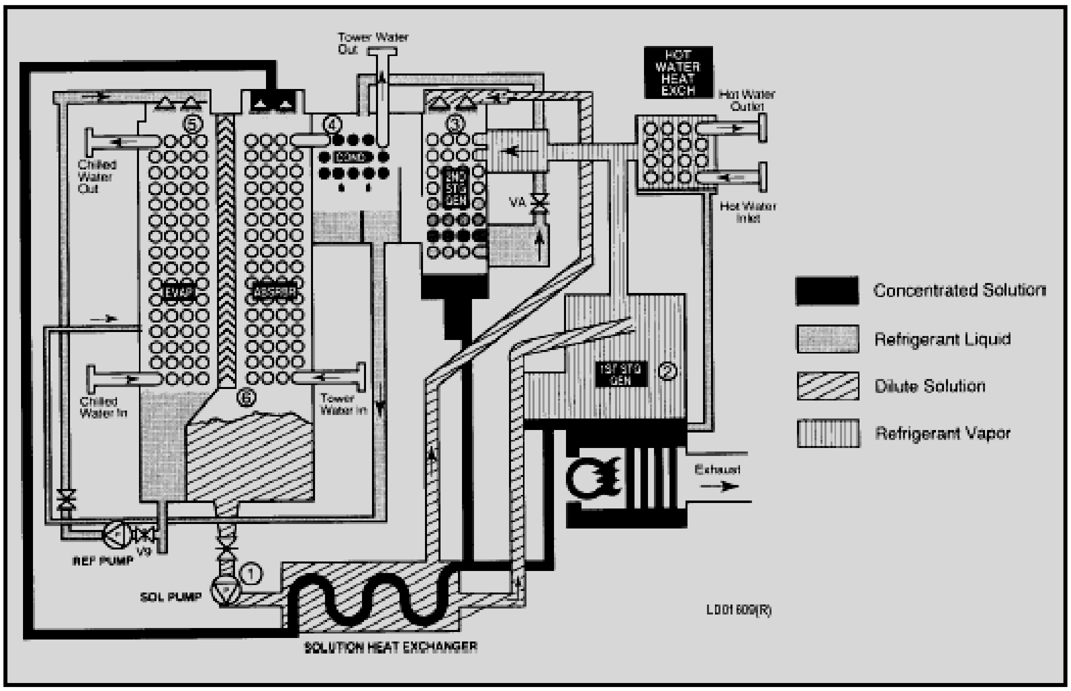


Figure 8: Chilling Cycle in an Absorption Chiller (York International Corporation, 1997).

Electric Chiller

Electric chillers provide chilled water for all air conditioning applications that use central station air handling or terminal units and are driven by electricity. The main energy conversion cycle in air-conditioning is the reversed-Rankine or vapor-compression cycle. The compressor under the input of work, compresses refrigerant vapor from the evaporator and delivers it to the condenser. The vapor condense, releasing the heat of condensation that is used either for heating purposes (heat pump) or rejected as waste heat to the environment (air-conditioning). The liquid refrigerant flows from the condenser through the expansion valve into the evaporator. Here it evaporates while absorbing energy, either extracting heat from the environment (heat pump) or cooling space or product (air -conditioning) (Bullard and Radermacher, 1994).

Operation data from a commercially available electric chiller, (York International Corporation, 1999), was used to create the GEMIS model for the electric chiller. Models sizes range from 211-kW to 879-kW; a 195.5-kW chiller was used to supply the cooling energy usage of the building.

Assumptions made were that the auxiliary materials in the chiller were made from 98% steel and 2% Copper and the coefficient of performance (COP) was 4.6.

2.2.3 Heating System

Gas Boiler

The main type of boiler that is fueled by natural gas is fire-tube. Fire-tube boilers consist of a series of straight tubes that are housed inside a water-filled outer shell. The tubes are arranged so that hot combustion gases flow through the tubes. As hot gases flow through the tubes, they heat the water that surrounds the tubes. The water is confined by the outer shell of the boiler. To avoid the need for a thick outer shell, fire-tube boilers are used for lower-pressure applications (Oland, 2002).

Boiler efficiency is a function of boiler losses and combustion losses. It can be characterized as the amount of heat captured by the boiler and transferred to the water, divided by the heat input. The heat that was not transferred to the water manifests itself in a number of losses that include: flue-gas losses, radiant heat losses, blow-down losses, and unaccounted losses (Oland, 2002).

Flue-gas losses are often the primary cause for reduced boiler efficiency. Energy is wasted whenever heated flue gas is carried out of the boiler and up the stack. Flue-gas temperature is related to boiler load. In general, as boiler load increases, the flue-gas temperature increases. Installation of equipment to recover some of this heat can have a beneficial effect on efficiency, but removing too much heat can cause problems such as corrosion, especially when water condenses on boiler equipment. Air in excess of that required for complete fuel combustion represents a major flue-gas loss. Because the fuel supplies energy required to increase the temperature of excess air, controlling the amount of air that is supplied to a boiler has a direct impact on boiler efficiency. The loss is a function of the amount of excess air that passes through the boiler and the temperature of the excess air that discharges from the stack. Energy required to raise the temperature of excess air is wasted because it is not used to heat water. If the water vapor content of the excess air is high, even more energy is required to superheat the water vapor. Although combustion of any fuel results in some degree of flue-gas loss, solid fuels require more excess air for complete combustion than do gaseous fuels (Oland, 2002).

Although combustion with insufficient air decreases combustion efficiency, it is a very effective technique for reducing NOx formation. A lower flame temperature associated with incomplete combustion decreases the amount of thermal NOx that forms. Selection of a low-emission boiler and combustion equipment often requires a compromise between efficiency and NOx formation. For greatest efficiency, a boiler should be fitted with proper combustion equipment, including a control system that is capable of adjusting the fuel-air mixture so that little or no CO and soot are produced. Additional air that is required to complete the combustion process is sometimes provided in stages. Staged combustion is a NOx control technique based on the fact that combustion at either very low or very high excess air levels results in reduced NOx formation. By mixing air and fuel at two or more locations inside a boiler, it is possible to create zones with high and low excess air levels. Air that is injected into a boiler at different points or stages in the combustion process is known as staged combustion air (SCA).

New boilers and combustion equipment that are well-designed are capable of achieving both high efficiency and low NOx formation. However, for existing boilers, changes in firing profile may change the absorption profile, temperature profile, and carbon burnout of a boiler, thereby affecting boiler efficiency (Oland, 2002).

The reaction of hydrogen atoms in fuel with oxygen molecules in air produces heat and water vapor. When the water vapor leaves the stack, it reduces the available energy by carrying away the associated latent heat of vaporization. Reducing the temperature of the flue gas as a means of lowering the heat loss is an effective way to conserve energy, but it can lead to serious corrosion problems. Because natural gas has relatively high hydrogen content when compared to coal, this form of heat loss is higher for natural gas-fired boilers than for comparable size coal-fired boilers (Oland, 2002).

Moisture in fuel represents another form of heat loss. Like the phenomenon just described, the water vapor leaving the stack reduces the available energy by carrying away the associated latent heat of vaporization. As water vapor from the fuel is superheated, additional heat loss is experienced. The wasted energy from this form of heat loss can be significant for solid fuels but tends to be less for gaseous fuels, which usually have lower moisture content (Oland, 2002).

Radiant heat loss consists of both radiant and convection heat losses from the outer surfaces of a boiler, which are typically above ambient temperature. These losses do not vary significantly in magnitude with boiler load because the outer surface temperature of the boiler remains essentially constant while in operation. However, these losses as a percentage of boiler output get worse whenever the load diminishes. Two ways to reduce radiant heat loss include adding thermal insulation to outer boiler surfaces and operating the boiler at the lowest temperature consistent with system and boiler manufacturer requirements (Oland, 2002).

Buildup of soluble salts and accumulation of other solids in the water passages of a boiler can impede heat transfer and eventually restrict flow through boiler passages. Use of chemicals that impede scaling and regular blow-downs can help control this problem, but the hot water and solid particles that discharge during a blow-down represent wasted energy. Installing a heat recovery system can reduce boiler losses due to blow-downs. By using chemicals to control scaling, it may be possible to reduce the blow-down rate. Note that blow-down heat recovery equipment is usually cost-effective only for systems that use continuous rather than intermittent blow-down (Oland, 2002).

A relatively small but important form of heat loss is characterized as unaccounted losses. These losses, which are not related to the combustion process, are associated with cyclic rather than continuous boiler operations. They include prepurge and postpurge losses, natural-draft losses, and off-line shell losses. Prepurge and postpurge losses involve forcing air through the boiler to remove unburned combustibles before startup and after shutdown. When this operation is performed, the flowing air removes some thermal energy from the boiler. Similar to purging losses, natural-draft losses occur when the boiler is shut off and air circulates naturally through the boiler. Off-line shell losses are radiant heat losses that occur after the boiler is shut off. Firetube boilers typically have off-line shell losses much less than comparable size watertube boilers because the shell temperature of a firetube boiler is more of a function of the water temperature than the combustion gas temperature (Oland, 2002).

Heating systems for commercial buildings typically exhibit a wide range of heating demands throughout the heating season. To minimize unaccounted heat losses associated with cyclic operation, there may be advantages in selecting multiple boilers instead of one or two large boilers. In this approach, at least some of the smaller units operate more or less continuously (Oland, 2002).

The main emissions from natural gas-fired boilers include NOx, CO, CO_2, CH_4, N_2O, VOC, trace amounts of SO_2, and PM (EPA AP-42, 1999).

The principal mechanism of NOx formation in natural gas combustion is thermal NOx which occurs through the thermal dissociation and subsequent reaction of N_2 and O_2 molecules in the combustion air. The formation of thermal NOx is affected by: oxygen concentration, peak temperature, and time of exposure to peak temperature; as these factors increase NOx emission levels increase. The rate of CO emissions from boilers depends on the efficiency of natural gas combustion. In some cases, the addition of NOx control systems may reduce combustion efficiency, resulting in higher CO emissions relative to uncontrolled boilers). The rate of VOC emissions from boilers also depends on combustion efficiency. VOC emissions are minimized by high combustion temperatures, long residence times at those temperatures, and turbulent mixing of fuel and combustion air. SO_2 emissions from natural gas-fired boilers are low because pipeline quality of natural gas has sulfur levels of 2000 grains per million cubic feet. Unprocessed natural gas have higher SO_2 emissions due to higher sulfur levels in the natural gas, also, sulfur containing odorants (added to natural gas for detecting leaks) leads to small amounts of SO_2 emissions from the boiler (EPA AP-42, 1999).

Greenhouse gases (CO_2, CH_4, and N_2O) emissions are all produced during natural gas combustion. Nearly all of the fuel carbon is converted to CO during the combustion process, which is independent of boiler type. Fuel carbon not converted to CO_2 results in CH_4, CO, and/or VOC emissions, which is due to incomplete combustion and are insignificant compared to CO_2 levels. N_2O emissions are minimized with high combustion temperatures and low excess oxygen levels (<1%); methane emissions are minimized in similar conditions. Particulate matter emission from natural gas combustion is low because natural gas is a gaseous fuel (less than one micrometer in size) (EPA AP-42, 1999).

1-MW gas boiler with thermal efficiency of 88.7% was used to supply the required heat in the scenarios. The emissions from the boiler were acquired from EPA's AP-42.

2.2.4 Cogeneration Systems

Solid Oxide Fuel Cell

The origin of fuel cells dates back to 1839, while the formative history was based on the work of Sir Francis Bacon and later efforts in the 1960's in the space program. Gas industry efforts and other developments by DOE, GRI, and SPRI during the 1980s and 1990s led to the first commercial fuel cell product in 1991 (Liss, 1999).

The main difference among fuel cell types is in the electrolytic material. Each different electrolyte has benefits and detriments based on cost, operating temperature, achievable efficiency, power to volume (or weight) ratio, and other operational considerations. Fuel cell designs include Molten Carbonate Fuel Cell (MCFC), Phosphoric Acid Fuel Cell (PAFC), Proton Exchange Membrane Fuel Cell (PEM), and Solid Oxide Fuel Cells (SOFC). Although fuel cells feature high efficiency, low emissions, and high reliability, they are not available commercially at comparable price to other prime movers. For instance, the only commercially available fuel cell is the ONSI PAFC introduced in 1991 and its cost is 10-20 times higher than other prime movers (Liss, 1999). Electrical efficiency of MCFC is 50-57%, PAFC is 40-45%, PEM is up to 50%, and SOFC is 45-50% (ONSITE SYCOM, 1999).

Recently, resources have been devoted to developing PEM fuel cell with the promise of being commercially available by 2001. GRI is focused on the development of the SOFC due to the potential for low first cost and high efficiency. Low first cost is achieved by a simplified balance-of-plant system; including internal reforming and reduced needs for fuel clean-up (Liss, 1999).

Fuel Cells need hydrogen, and some like MCFC and SOFC can also utilize carbon monoxide. Hydrogen and carbon monoxide can be produced from fuels such as natural gas, for example, by steam reforming, while some fuel cells can reform internally (Siemens Westinghouse).

A fuel cell consists of two electrodes separated by an electrolyte. As shown in Figure 9, hydrogen fuel is fed into the anode of the fuel cell. Oxygen (or air) enters the fuel cell through the cathode. With the aid of a catalyst, the hydrogen atom splits into a proton and an electron. The proton passes through the electrolyte to the cathode. As they flow through an external circuit connected as a load, the electrons create a DC current as they return to the cathode. At the cathode, electrons combine with hydrogen and oxygen producing water and heat. The part of a fuel cell that contains the electrodes and electrolytic material is called the "stack" which is major component of the cost of the total system. Stack replacement is very costly but becomes necessary when efficiency degrades as stack operating hours accumulate (Resource Dynamic Cooperation, 1999).

Significant heat is released in a fuel cell during electric generation. The PAFC and PEMFC operate at lower temperatures and produce lower grades of waste heat generally suitable for commercial and industrial CHP applications. The MCFC and SOFC operate at much higher temperatures and produce heat that is sufficient to generate additional electricity with a steam turbine or a microturbine hybrid gas turbine combined cycle (ONSITE SYCOM, 1999).

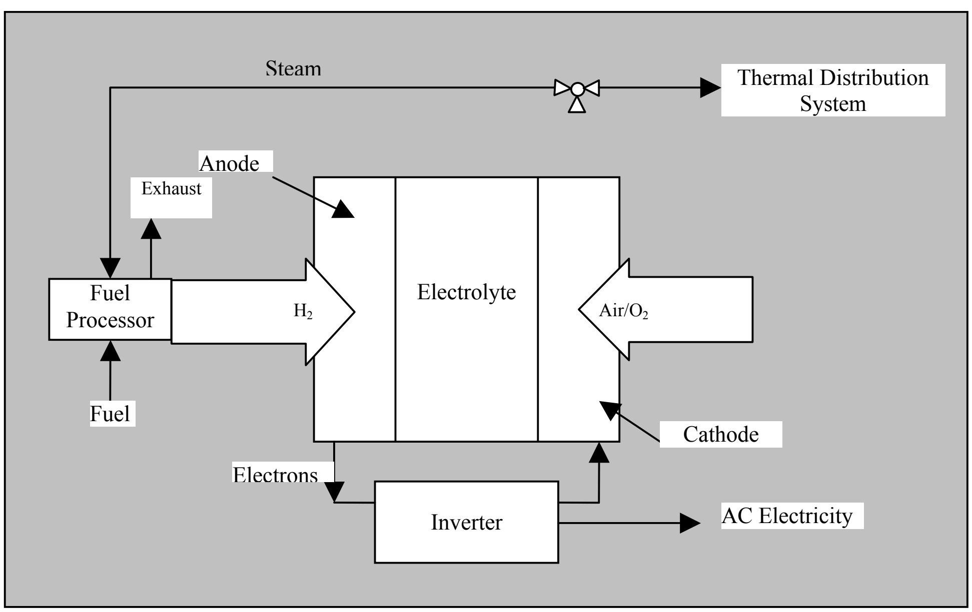


Figure 9: Schematic of a Typical Fuel Cell (Resource Dynamic Cooperation, 1999).

Solid oxide fuel cells could be used in high-power applications including industrial and large-scale central electricity generating stations. Small units (25-100 kW) are currently being demonstrated. A solid oxide system usually uses a hard ceramic material instead of a liquid electrolyte, allowing operating temperatures to reach 1,800º F (Resource Dynamic Cooperation, 1999). One type of SOFC is planar solid-oxide fuel cell. In planar SOFC, shown in Figure 10, oxygen diffuses from the air side (cathode) and reacts with the fuel, H_2 and CO_2, produced by reforming natural gas. The air exhaust is hot oxygen depleted-air, and the fuel exhaust consists of steam, CO and unburned fuel whose respective concentrations depend on the inlet fuel used and on the fuel utilization (Lygre et al., 2001).

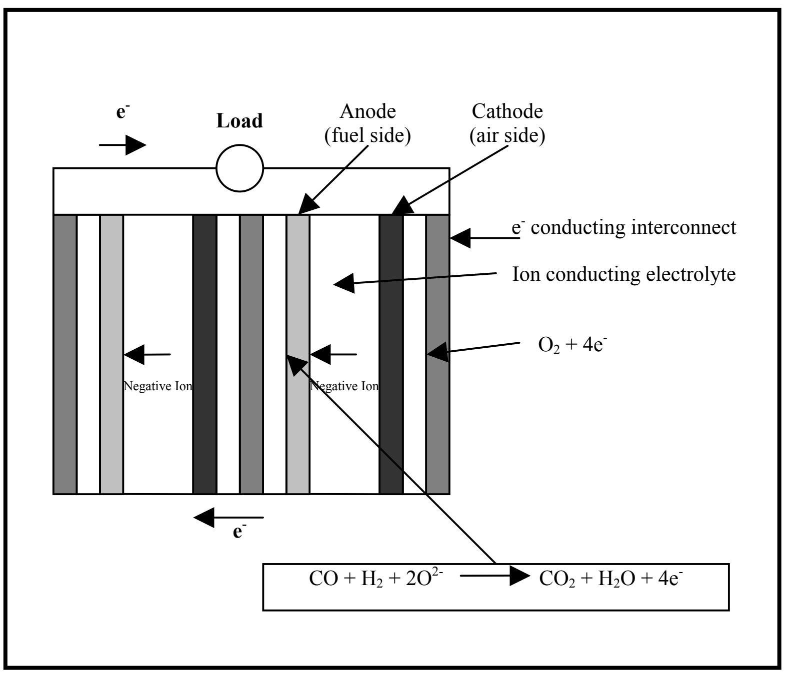


Figure 10: Schematic of Planar SOFC (Lygre et al., 2001).

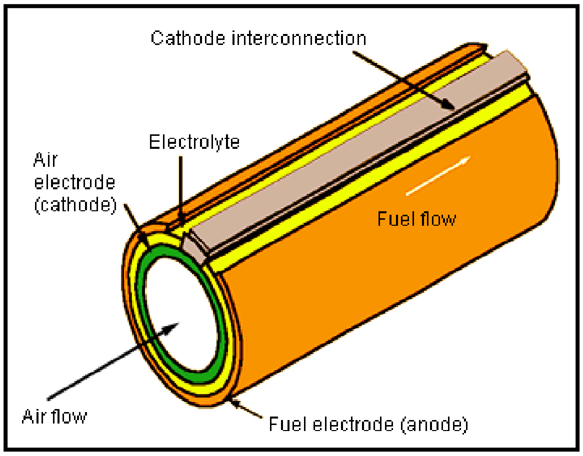


Figure 11: Schematic of Tubular Design SOFC (Bessette et al., 2001).

The model of SOFC used in this study was tubular design that needs no seals and provides a means of accommodating thermal expansion. The Siemens Westinghouse SOFC is a tubular design configured as a single cell per tube. The cell is built up in layers on the air electrode (cathode) with an axial interconnection that makes the cathode accessible and allows cells to be connected together in series. Figure 11 shows a schematic of tubular design SOFC (Bessette et al., 2001).

To generate electricity efficiently, the cell must be maintained at an operating temperature of about 1000° C, air must be supplied to the cell interior using an air delivery tube, and fuel is delivered to the cell exterior. At open circuit, a potential in the range of 900-mV to 1-V will be generated per cell, thus cells are connected in series to build voltage. Power produced is proportional to the active surface area of the cells. At atmospheric pressure, a uniform temperature of 1000° C, 85% fuel utilization, and 25% air utilization, a single tubular SOFC will generate power of up to 210 W dc. The cells are arranged in rows separated by stack reformers (Bessette et al., 2001). Radiation from the cells to the in-stack reformers provides the heat to reform the incoming fuel after it is mixed with recycled depleted fuel that provides water vapor for the reformation reaction.

A 110-kw solid oxide fuel cell (SOFC) cogeneration process with 80% overall efficiency, 47% of which was electrical and 26-33% was thermal, was used in the model. The difference in thermal efficiency between the 26% and 33% SOFC was that the 26%-thermal SOFC used part of the generated heat to provide heat for the fuel reformation process. The SOFC process model was adapted from Siemens SOFC.

Assumption made was that natural gas was reformed to hydrogen gas without loss. Carbon dioxide emission data were obtained from the Arthur D Little report (Little, 2000).

Microturbine

Microturbines date back to 1950-1970, with the automotive market looking at gas turbine products. Stationary market interest was spurred by Public Utility Regulatory Policy Act (PURPA) in the mid-1980s and accelerated during the 1990s as the automotive market re-assessed small gas turbine in hybrid vehicles and several manufacturers pursued opportunities in the distributed generation market. Several high profile emerging products will significantly shape the microturbine market during the next five years (Liss, 1999).

Microturbines, still an emerging technology, are small gas turbines under 300 kW size range. These products are high-speed units with shafts rotating at 50,000-120-000 rpm, mainly using recuperation to boost efficiency and integral high speed alternators that produce an electrical output transformed to more conventional 50-60 Hz power. Current products are generally sized at 25-75 kW and achieve efficiencies of 24-30% (LHV) (Liss, 1999).

Simple microturbines consist of a compressor, recuperator, combustor, turbine, and generator. The compressors and turbines are typically radial-flow designs, and look much like automotive engine turbochargers. Most designs are single-shaft and use a high-speed permanent magnet generator producing variable voltage, variable frequency alternating current (AC) power. Most microturbine unit designs are currently designed for continuous-duty operation and are recuperated to obtain higher electric efficiencies. Air bearings reduce system complexity and are employed by several of current microturbine manufacturers. When microturbines are run on natural gas, as they most commonly are, they often require a gas compressor to deliver fuel into the combustion chamber at specified pressures. Hot exhaust gas from the turbine section is available for CHP applications. Most designs incorporate a recuperator that limits the amount of heat available for CHP. Recovered heat can be used for hot water heating or low pressure steam applications (ONSITE SYCOM, 1999). Refer to Figure 12 for a schematic of a typical microturbine.

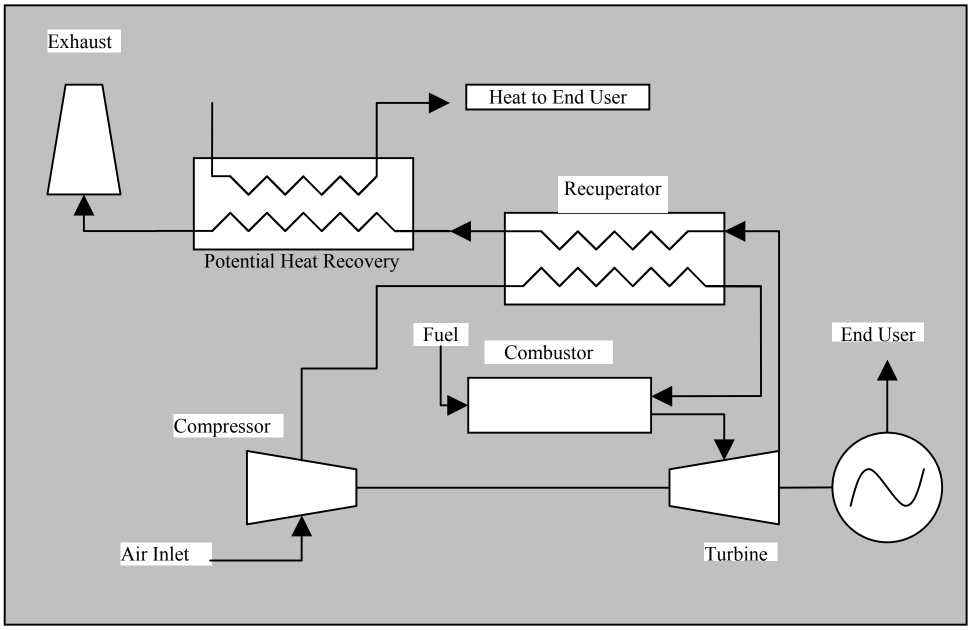


Figure 12: Schematic of Typical Microturbine (Resource Dynamic Cooperation, 1999).

Microturbines are just emerging as a future distributed resource that will be ideally sized to meet the electric load profiles of many commercial and institutional end-users. Exhaust heat can be recovered for hot water or steam loads.

The primary pollutants from gas turbine engines are NOx, CO, and low VOC. Similar to a gas boiler, NOx formation depends on the high temperatures developed in the combustor while CO and VOC result from incomplete combustion. Ash and metallic additives to the fuel contribute to PM in the exhaust and the SOx emissions depend on the sulfur content of the fuel. Emissions from gas turbine indicate that the turbine's operating load has a considerable effect on the resulting emission levels. Gas turbines are typically operated at high loads (greater than or equal to 80% of rated capacity) to achieve maximum thermal efficiency and peak combustor zone flame temperatures. At reduced loads, or during periods of frequent load changes, the combustor zone flame temperatures are expected to be lower the high load temperatures, yielding lower thermal efficiencies and more incomplete combustion (EPA AP-42, 1999). The emission factors used in this study are for gas turbines operating under high load conditions.

A 60-kW natural gas-fired microturbine cogeneration process with 80% overall efficiency, 28% of which was electrical and 52% was thermal, was used in the model. The microturbine process model was adapted from a Capstone microturbine (Capstone Turbine Corp., 2001).

Assumptions made were that the auxiliary materials in the microturbine were made of steel. Oxygen content in the gas was assumed to be 15% by volume.

Internal Combustion Engines

The formative history of reciprocating engines dates to the 1880-1920 time period. Stationary engine application has grown consistently over the decades—including significantly growth in the past ten years. With continued product advancements and a reasonable regulatory environment, reciprocating engines, also known as internal combustion engines (ICE), will continue as a low-cost and a competitive prime mover (Liss, 1999).

The ICE, (reciprocating engine or piston driven engine), requires fuel, air, compression, and a combustion source to function. The four-stroke, spark-ignited reciprocating engine has an intake, compression, power and exhaust cycle. In the intake phase, as the piston moves downward in its cylinder, the intake valve opens and the upper portion of the cylinder fills with fuel and air. When the piston returns upward in the compression cycle, the spark plug emits a spark to ignite the fuel/air mixture. This controlled reaction, or "burn", forces the piston down thereby turning the crank shaft and producing power. In the exhaust phase, the piston moves backup to its original position and the spent mixture is expelled through the open exhaust valve. Figure 13 shows a schematic of a typical internal combustion engine.

Energy in the fuel is released during combustion and is converted to shaft work and heat. Shaft work drives the generator while heat is liberated from the engine through coolant, exhaust gas and surface radiation. Approximately 60-70% of the total energy input is converted to heat, some of which can be recovered from the engine exhaust and jacket coolant, while smaller amounts are also available from the lube oil cooler and the turbocharger's intercooler and after-cooler (if so equipped). Steam or hot water can be generated from recovered heat that is typically used for space heating, reheat, domestic hot water and absorption cooling.

Heat in the engine jacket coolant accounts for up to 30% of the energy input and is capable of producing 200°F hot water. Some engines, such as those with high pressure or ebullient cooling systems, can operate with water jacket temperatures up to 265°. Engine exhaust heat is 10-30% of the fuel input energy. Exhaust temperatures of 850°-

1200°F are typical. Only a portion of the exhaust heat can be recovered since exhaust gas temperatures are generally kept above condensation thresholds. Most heat recovery units are designed for a 300°-350°F exhaust outlet temperature to avoid the corrosive effects of condensation in the exhaust piping. Exhaust heat is typically used to generate hot water to about 230°F or low-pressure steam (15 psig). By recovering heat in the jacket water and exhaust, approximately 70-80% of the fuel's energy can be effectively utilized for a typical spark-ignited engine (ONSITE SYCOM, 1999).

The most common method of recovering engine heat is the closed-loop cooling system. These systems are designed to cool the engine by forced circulation of a coolant through engine passages and an external heat exchanger. An excess heat exchanger transfers engine heat to a cooling tower or radiator when there is excess heat generated. Closed-loop water cooling systems can operate at coolant temperatures between 190°-250°F (ONSITE SYCOM, 1999).

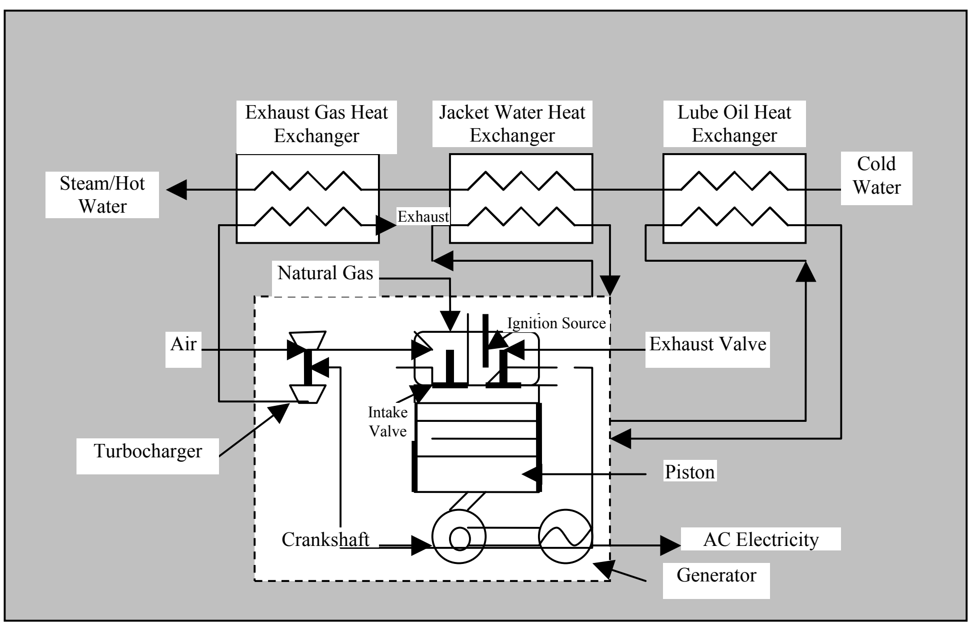


Figure 13: Schematic of a Typical Internal Combustion Engine (Resource Dynamic Cooperation, 1999).

Ebullient cooling systems cool the engine by natural circulation of a boiling coolant through the engine. This type of cooling system is typically used in conjunction with exhaust heat recovery for production of low-pressure steam. Cooling water is introduced at the bottom of the engine where the transferred heat begins to boil the coolant generating two-phase flow. The formation of bubbles lowers the density of the coolant, causing a natural circulation to the top of the engine. The coolant at the engine outlet is maintained at saturated steam conditions and is usually limited to 250°F and a maximum of 15 psig. Inlet cooling water is also near saturation conditions and is generally 2°- 3°F below the outlet temperature. The uniform temperature throughout the coolant circuit extends engine life, contributes to improved combustion efficiencies and reduces friction in the engine (ONSITE SYCOM, 1999).

Commercially available reciprocating engines for power generation range from 0.5-kW to 6.5-MW. The wide power range and operating flexibility make reciprocating engines suitable for substations and small municipalities plus commercial, industrial, institutional, and even residential applications (Distributed Energy Resources, 2001). Electrical energy efficiency is approximately 40%. System energy efficiencies (thermal and electrical) can approach 80%.

Gas engines achieve shaft efficiency of 30-40% (LHV). Stoichiometric engines have lower efficiencies while the higher numbers apply to larger lean-burn or dual-fuel/micro-pilot engines. Lean-burn engines in the 0.5-4 MW size range typically achieve efficiency in the 37-41% range (Liss, 1999).

Most commercial end-users have a varying electric load profile, i.e., high peak loads during the day and low loads after business hours at night. Natural gas reciprocating engines are a popular choice for commercial CHP due to good part-load operation, ability to obtain an air quality permit and availability of size ranges that match the load of many commercial and institutional end-users. Reciprocating engines exhibit high electric efficiencies meaning that there is less available rejected heat. This is often compatible with the thermal requirements of the end-user (ONSITE SYCOM, 1999).

The primary criteria pollutants from natural gas-fired ICE's are NOx, CO, and VOC. Similar to the case of gas boiler, NOx formation depend on combustion temperature while CO and VOC result from incomplete combustion. PM emissions include trace amounts of metals, non-combustible inorganic material, and condensable semi-volatile organics, which result from volatilized lubricating oil, engine wear, or from products of incomplete combustion (EPA, AP-42, 1999).

Two internal combustion engines (ICE) sizes were used in this study:

(1) 3-MW ICE: cogeneration process with 80% overall efficiency, 39% of which is electrical and 41% is thermal. ICE process model was adapted from Caterpillar gas engine (Caterpillar Inc., 1997).

(2) 143-kW ICE: cogeneration process with 80% overall efficiency, 29% of which is electrical and 51% is thermal. ICE process model was adapted from Caterpillar gas engine (Caterpillar Inc., 1997).

Assumptions made were that the auxilary materials in the ICE were made of steel and oxygen content in the gas was 5% by volume. A 3-way catalyst was used for emission control and emissions from the ICE were obtained from EPA's AP-42.

2.3 Scenario Descriptions

A set of scenarios were designed for the building which had electrical loads for equipment and light, cooling, and thermal loads for space conditioning and water heating.

Three types of electric generation systems were used for the analysis to supply electrical power:

1. US average electric generation mix
2. A 100% mix natural gas combined cycle (NGCC)
3. On-site cogeneration

Two types of thermal generation systems are used:

1. Natural gas-fired boilers
2. On-site cogeneration

Two types of cooling generation systems were used:

1. Absorption chiller
2. Electric chiller

Cogeneration processes could be operated in various combinations that could be used to optimize the electrical or thermal production from the processes. The three basic operational strategies considered in this study were baseline, thermal, and electrical load following cases. Table 4 provides a summary of the strategies analyzed. Lists of processes and scenarios used in the study are given in Appendix A. A detailed description of the scenarios follows in this section.

Table 4: Scenario Descriptions and Strategies Constructed for the Study.

Scenario	Electric Load	Heating Load	Cooling Load	
Baseline Cases	Average electric generation mix	Gas boiler	Option (1): Absorption chiller driven by heat from gas boiler. Option (2): Electric chiller driven by electricity from the average electric mix.	
	Gas-fired combined cycle	Gas boiler	Option (1): Absorption chiller driven by heat from gas boiler. Option (2): Electric chiller driven by electricity from the NGCC.	
Scenario	**Electric Load**	**Heating Load**	**Cooling Load**	
			ELF	**TLF**
Thermal Load Following Cases	*Co-generated electricity* from a cogeneration process was used to meet part/all of the electrical requirement of the building; *supplemental electricity* could be added from the *average electric mix*[9].	Heat generated from a cogeneration process was used to drive a gas boiler to meet the thermal energy use of the building.	-	Absorption chiller driven by heat generated from the cogeneration processes was used to meet the cooling load of the building.

[9] Note: supplemental electricity could also be added from the NGCC, although such scenarios were investigated in the model, they were not used in the analysis section.

Electrical Load Following Cases	Electricity generated from a cogeneration process.	*Co-generated heat* from a cogeneration processes was used to drive a gas boiler to meet part/all of the heating requirement of the building.	*Option (1):* Electric chiller driven by electricity from a cogeneration process. *Option (2):* Absorption chiller driven heat from a cogeneration process. *Option (3):* A combination of electric and absorption chillers (driven by part of the co-generated heat from the cogeneration processes).	-

2.3.1 First Scenario: Baseline

Baseline cases refer to systems that use conventional power generation processes. The two processes used in the model are U.S. average electric generation mix and natural gas-fired combined cycle electric generation. These processes are used to satisfy the electric load of the building which is mainly composed of equipment and light. The cooling demand of the building is satisfied using absorption or electric chiller and the heating demand is satisfied by using a gas boiler.

Option (1):

U.S. average electric generation mix is used to provide the electric load of the building. The cooling demand of the building, in summer months (May and August), is satisfied by using:

(a) Absorption chiller, in one scenario; or

(b) Electric chiller, in a second scenario.

Heating demand of the building during winter (January) is satisfied using a 1-MW gas-fired boiler with 89% thermal efficiency.

Option (2):

Natural gas-fired combined cycle electric generation (NGCC) is used to provide the electric load of the building. The cooling and heating loads are satisfied using the same processes described in "Baseline option (1)".

2.3.2 Second Scenario: Thermal Load Following

Cogeneration processes were used to satisfy the thermal load of the building, which was mainly space and water heating, and cooling. The cooling demand of the building in summer months (May and August) was satisfied by using an absorption chiller, driven by the heat produced from the cogeneration process, in one scenario; or by an electric chiller, driven by electricity produced from the cogeneration process, in a second scenario.

The co-generated electricity produced from the cogeneration process following the thermal load of the building was used to satisfy part or all of the electric demand of the building (equipment and light). If supplemental electricity was required to meet the electric demand, it could be imported from the electric grid (powered by the average electric power generation mix). Although not accounted for in the model, any excess electricity produced could be stored for backup or sold back to the electric grid.

Cogeneration System Option (1):

A 110-kw solid oxide fuel cell (SOFC) cogeneration process with 80% overall efficiency, 47% of which was electrical and 26-33% was thermal, was utilized to meet the thermal load requirement of the building.

Cogeneration System Option (2):

A 60-kW natural gas-fired microturbine cogeneration process with 80% overall efficiency, 28% of which was electrical and 52% is thermal, was operated to meet the thermal load requirement of the building.

Cogeneration System Option (3):

A 3-MW internal combustion engine (ICE) cogeneration process with 80% overall efficiency, 39% of which was electrical and 41% was thermal, was operated to meet the thermal load of the building.

Cogeneration System Option (4):

A 143-kW internal combustion engine (ICE) with 80% overall efficiency, 29% of which was electrical and 51% was thermal, was operated to meet the thermal load of the building.

2.3.3 Third Scenario: Electrical Load Following Case

In this scenario, the four cogeneration options (same processes as those described in the third scenario under thermal load following), were used to satisfy the electric load of the building (equipment and light only). The cooling demand of the building, in summer months (May and August), was satisfied by using:

(a) Electric chiller, driven by the electricity produced from the cogeneration process, in one scenario; or

(b) A combination of absorption and electric chiller, driven by the cogeneration process, in a second scenario.

While following the electric load of the building, heat was produced from a cogeneration process which was used to satisfy part or all of the thermal demand of the building (mainly water heating). In addition, the co-generated heat was also used to drive the absorption chiller for cooling. The cogeneration process was operated to satisfy additional cooling requirements. A gas-fired boiler was used supplemental heat was required to meet the thermal demand.

2.4 Calculation Methodology

(A) The basic formula used to calculate the *electrical energy* co-generated from a cogeneration process for a given time step while following the thermal load of the building was:

Equation 1: Electrical Energy Co-generated from a Cogeneration Process (TLF)

$$P_u = [Q_T] * [\eta_e / \eta_t] \qquad (1)$$

where,

P_u: electrical energy available for utilization [kWh],

Q_T: total thermal energy used by the building [kWh],

η_e: electrical efficiency of the cogeneration unit, and

η_t: thermal efficiency of the cogeneration unit.

Note: the difference between the total electric energy use and the electric energy produced by a cogeneration process determined if electric energy produced was in excess or if supplemental electricity was required to meet the electric energy use of the building.

(B) The basic formula used to calculate the thermal energy co-generated from a cogeneration process for a given time step while following the electric load of the building was:

Equation 2: Thermal energy co-generated from a cogeneration process (ELF).

$$Q_u = [P_T] * [\eta_t / \eta_e] \qquad (2)$$

where,

Q_u: thermal energy available for utilization [kWh],

P_T: total electric energy used by the building [kWh],

η_e: electrical efficiency of the cogeneration unit, and

η_t: thermal efficiency of the cogeneration unit.

Note: the difference between the total thermal energy use of the building [Q_T] and the heat produced by a cogeneration unit [Q_u] determined if thermal energy was produced in excess or if supplemental heat was required to meet the thermal energy use of the building.

In cooling months (May and August), a cogeneration process could be run to meet the cooling load[10] of the building in three different ways:

(1) Electric chiller only,

(2) Absorption chiller only, or

(3) Combination of electric and absorption chillers.

In the first case, a cogeneration process was operated to meet the equipment and lighting load[11] of the building, which included an electric chiller for the cooling load. In the second case, a cogeneration process was operated to meet the equipment and lighting load of the building, and the cooling load was met by an absorption chiller, which was driven by the otherwise wasted heat from the cogeneration process. In the third case, a cogeneration process was operated to meet the equipment and lighting load, and the cooling load was met by a combination of electric and absorption chillers (the waste heat was utilized to run an absorption chiller).

To calculate the thermal energy co-generated from a cogeneration process while following the electric load in each of the previous three cases, the following formulas were used:

(1) Cooling load met by an electric chiller:

Equation (2) was used to calculate the thermal energy produced where all the parameters remained the same and ($\boldsymbol{P_T}$) is the total electric energy use by the building including *equipment, lighting, and cooling*.

(2) Cooling load met by an absorption chiller:

Equation (2) was also used to calculate the thermal energy produced where all the parameters remain the same and ($\boldsymbol{P_T}$) is the electric energy use by the building including *equipment, lighting* only.

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[10] Electric load in January did not include cooling since cooling energy use was zero.

[11] For annual electric energy use, ventilation was also considered in addition to equipment, lighting, and cooling.

If the thermal energy produced by a cogeneration process was less than the thermal energy use of the building, a gas boiler was used to meet the thermal demand and the cogeneration process was operated to meet the cooling load by running an absorption chiller. Generally, the supplemental thermal load required for meeting the thermal demand was calculated as follows:

Equation 3: Supplemental thermal energy provided by a gas boiler.

$$Q_T - Q_u = Q_B \quad (3)$$

where,

Q_T: total thermal energy used by the building [kWh],

Q_u: thermal energy available for utilization [kWh], and

Q_B = supplemental thermal energy provided by a gas boiler.

On the other hand, if the thermal energy produced by a cogeneration process while following the electric load of the building was sufficient to meet the thermal energy use of the building but not enough to run an absorption chiller, then the cogeneration process was operated to meet the cooling load by running an absorption chiller.

(3) Cooling load met by a combination of absorption and electric chillers:

Equation (2) was also used to calculate the thermal energy produced from a cogeneration process where all the parameters remained the same and (***P_T***) is the electric energy use by the building including *equipment, lighting* only.

If the thermal energy produced by a cogeneration process was less than the thermal energy use of the building, a gas boiler was used to meet the thermal demand.

On the other hand, if the thermal energy produced by a cogeneration process while following the electric load of the building was sufficient to meet the thermal energy use of the building but not enough to supply the cooling load, then the cogeneration process was operated to meet the cooling load by running a combination of electric and absorption chillers. The power required to operate a cogeneration process to provide the supplemental cooling required was calculated as follows:

Equation 4: Power required for operating a cogeneration process to provide supplemental cooling (ELF-EC/AC).

$$P_{SC} = C * x \qquad (4)$$

where,

P_{SC}: is the electrical energy required to operate a cogeneration process to provide supplemental cooling required by the building [kWh], for given time step,

C: unmet cooling energy [kWh], and

x: fraction of electric energy required to supply 1-kWh of cooling energy by a cogeneration process, with a combination of absorption and electric chillers.

The fraction of electric energy required to supply 1-kWh of cooling energy by a combination of absorption and electric chillers driven by a cogeneration process (x) was calculated as follows:

Equation 5: Electric energy fraction required to supply 1-kWh of cooling energy by a combination of AC and EC (ELF).

$$\{x * (\eta_t / \eta_e) * COP_{AC}\} + \{x * COP_{EC}\} = 1 \qquad (5)$$

where,

x: fraction of electric energy required to supply 1-kWh of cooling energy by a cogeneration process,

η_e: electrical efficiency of the cogeneration unit,

η_t: thermal efficiency of the cogeneration unit,

COP_{AC}: Coefficient of performance of absorption chiller, and

COP_{EC}: Coefficient of performance of electric chiller.

Note that the equations and calculations described in this section were used in each of the following cases:

(a) For annual electric and thermal energy production from cogeneration processes: average annual energy use (thermal and electric) of the building was used.

(b) For a typical-day-in-a-month energy production (electric and thermal) from cogeneration processes: January was selected to represent heating month (winter) and May and August were chosen to represent cooling months (summer). The energy use (thermal and electrical) was summed for a typical day of a month:

$$P_d = \sum P_h$$

$$Q_d = \sum Q_h$$

where,

P_d and Q_d are daily electrical and daily thermal energy use, respectively, and

P_h and Q_h are hourly electrical and hourly thermal energy use, respectively.

(c) For hourly energy production from cogeneration processes: January was selected to represent heating month (winter) and May and August were chosen to represent cooling months (summer).

3.0 BUILDING LOAD CHARACTERISTICS AND SYSTEM ENERGY PRODUCTION

This chapter includes the following sections:

Section 3.1: Building Description

The section provides a description of the hypothetical office building.

Section 3.2: Building's Electrical and Thermal Loads

The section includes descriptions of the electric and thermal energy use of the building analyzed in annual, daily, and hourly basis. For the daily and hourly analysis three months are chosen: January, representing heating month, May and August, representing cooling months.

Section 3.3: System Energy Production

The section is subdivided into two sections:

Section 3.3.1: Thermal Load Following (TLF)

The section includes analysis of the electric energy produced from the cogeneration systems following the thermal load of the building and compared to the electric energy use of the building, which is provided by conventional systems (electric grid and NGCC).

Section 3.3.2: Electrical Load Following (ELF)

The section includes analysis of the thermal energy produced from the cogeneration systems following the electric load of the building and compared to the cooling and thermal energy use of the building, which is provided by conventional systems (electric chillers and gas boilers).

3.1 Building Description

The hypothetical case study was a commercial building (office) with an area of 100,000 square feet. The location chosen for the building was Columbia, Missouri, which is characteristic of the Midwest climate. The building characteristics were based on average commercial building in the U.S. obtained from the Commercial Building Energy Consumption Survey given (Sezgan *et al.*, 1995). The building descriptions, shown in Table 5, were used to obtain the electrical, heating, and cooling loads of the building through energy simulation software. Appendix C contains some of the building characteristics data used to construct the model.

Table 5: Hypothetical Building Description.

Description	Reference Case
Floor Area, ft^2	100000
Surface Area, ft^2	74443
Volume, ft^3	1300000
Surface Area Ratio	1.04
Total Conduction UA, Btu/h-F	17307.5
Average U-value, Btu/hr-ft^2-F	0.232
Wall Construction	8in brick/foam, R=7.0
Roof Construction	flat, r-19, R=10.9
Floor type, insulation	Slab on Grade, Ref=25.1,etc
Window Construction	4060 double, alum, U=0.52
Window Shading	None
Wall total gross area, ft^2	41110
Roof total gross area, ft^2	16667
Ground total gross area, ft^2	16667
Window total gross area, ft^2	24288
Results	
Energy use, k Btu	9498281
Total Electric, kWh	1696747
Internal/External lights, kWh	505611/134904
Heating/Cooling/Fan, kWh	0/447424/211504
Peak Electric, kW	678.9

3.2 Building's Electric and Thermal Loads

The office building electric and thermal loads (sometimes referred to as electrical and thermal demand or electrical and thermal energy use herein) is defined as follows:

> **Electric load:** is the electrical energy used by the building. The electric load consisted of office equipment and lighting, and it might include cooling depending on the scenario (as cooling could be met by electric chiller or absorption chiller).
>
> **Thermal Load:** is the thermal energy used by the building. The thermal load consisted mainly of water and space heating, and it might include cooling (absorption chillers) depending on the scenario.

Data from the Commercial Building Energy Consumption Survey (CBECS) were used to estimate the thermal and electric energy use of the hypothetical building modeled in this study (Sezgan et al., 1995).

The annual total electric energy consumption of the 100,000 square feet building was approximately 2,800,000 kWh/year. Refer to Figure 14 for the annual energy use of the building.

The thermal energy use (space and water heating) is approximately 820,000 kWh/year; the cooling energy use was 800,000 kWh/year (taking into account the boiler and chiller efficiencies); and the electric energy use (lighting, ventilation, and office equipment) was 1,400,000 kWh/year and 1,700,000 kWh, if cooling was included. As shown in Figure 15, the highest annual energy use was electrical while the heating and cooling energy use were approximately equal. If cooling was to be met by electricity, i.e., by an electric chiller, electrical consumption would be higher than if it was met by absorption chiller (note that electric energy consumption would be even higher if space heating was met by electricity).

As shown in Figure 16, the highest electrical consumption during a typical month, including the cooling energy occurred in August, followed by May and January. Electrical consumption was equal in January with or without cooling energy because there was no cooling demand in January. When comparing electrical consumption consisting of equipment and lights only, the electrical consumption was approximately constant throughout the three months.

Figure 17 shows the heating and cooling energy use of the building in a typical day in a month. As shown in Figure 17, during May and August, the heating energy use was low, which consisted mainly of water heating, whereas, heating energy use by the building was relatively very high in January because it included space and water heating. Peak cooling demand occurred in August followed by May and there was no cooling load in January.

Figure 18 shows the hourly electric energy use of the building during a typical day in January, May, and August. The figure shows that the hourly electrical consumption consisting of equipment and lighting only was almost constant and equal throughout the three months during peak hours, which were the working hours of the day (hours 9-17). During the early and late hours of the day, hours 1-8, and hours 18-24, respectively, the electrical energy consumption was much lower compared to the working hours (consumption was slightly higher in January compared to May and August during those particular hours). However, when cooling energy was added to the electric energy use, the electric load peaked during the working hours of the day as shown in Figure 18.

Figure 19 shows the hourly heating and cooling energy use of the building. In January, heating energy use peaked at hours 8 and 19 and decreases during the working hours of the day. On the other hand, in May and August, the heating energy use (mainly water heating) of the building peaked slightly during the working hours of the day. As discussed earlier, there was no cooling load in January and energy use was higher in August when compared to May when cooling loads were included. The difference between the energy use curves, with and without cooling shown in Figure 19, for May and August, indicated the potential for reducing electrical energy use with the use of absorption chillers, which could utilize the heat co-generated from the cogeneration processes.

Appendix D contains the electrical, cooling, and heating energy use of the building: Table D-15 shows the annual electric use of the building; Table D-16 shows the annual energy use of the building; Table D-17 shows the daily energy use of the building; Tables D-18, D-19, and D-20 show the hourly electrical, cooling, and heating loads of the building in the January, May, and August, respectively.

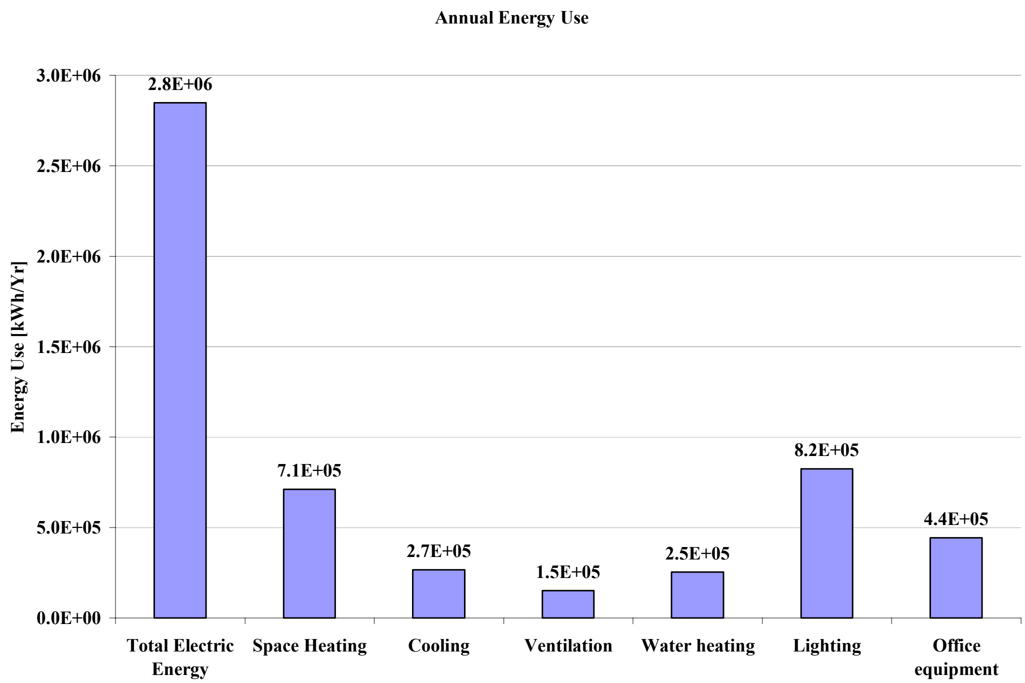

Figure 14: Annual Energy Use of the Building.

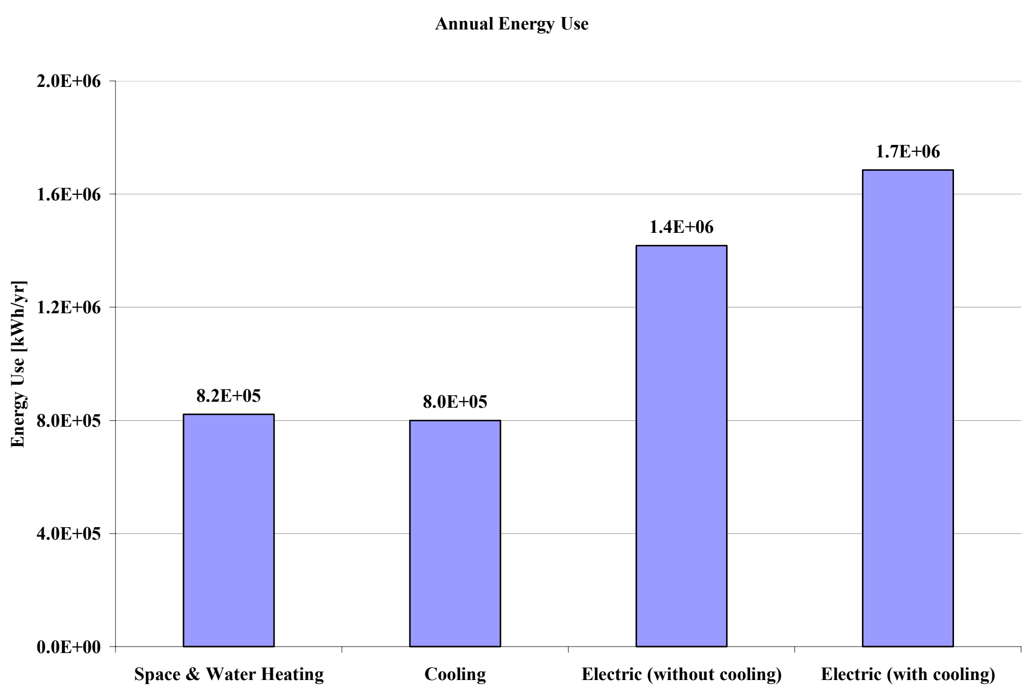

Figure 15: Annual Energy Use of the Building (considering boiler and chiller efficiencies).

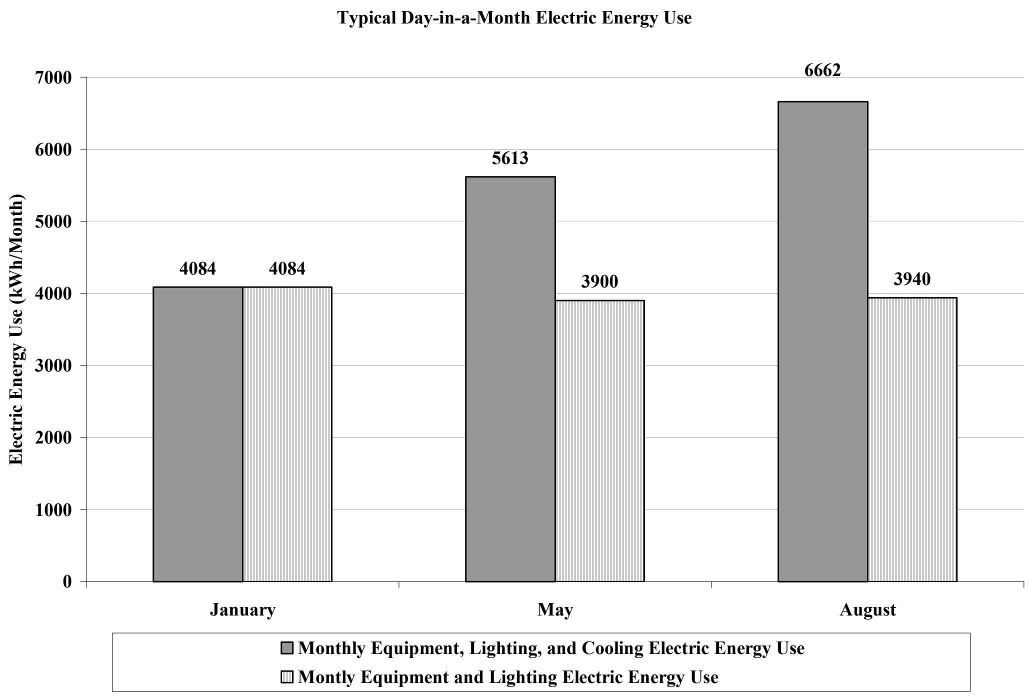

Figure 16: Typical Day-in-a Month Electric Energy Use of the Building.

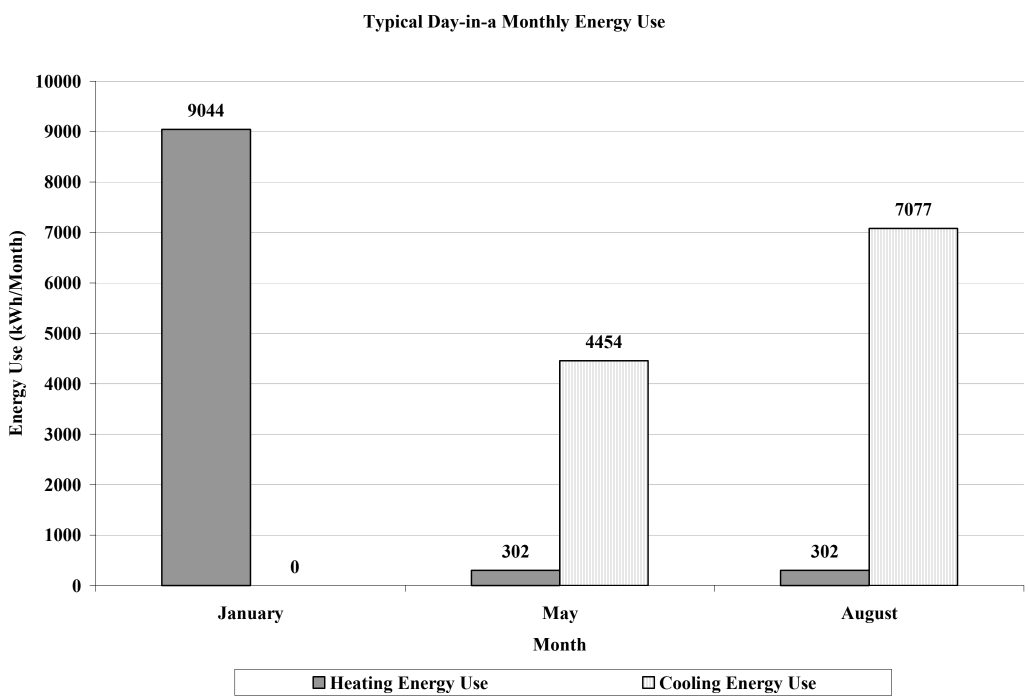

Figure 17: Typical Day-in-a Month Energy Use of the Building.

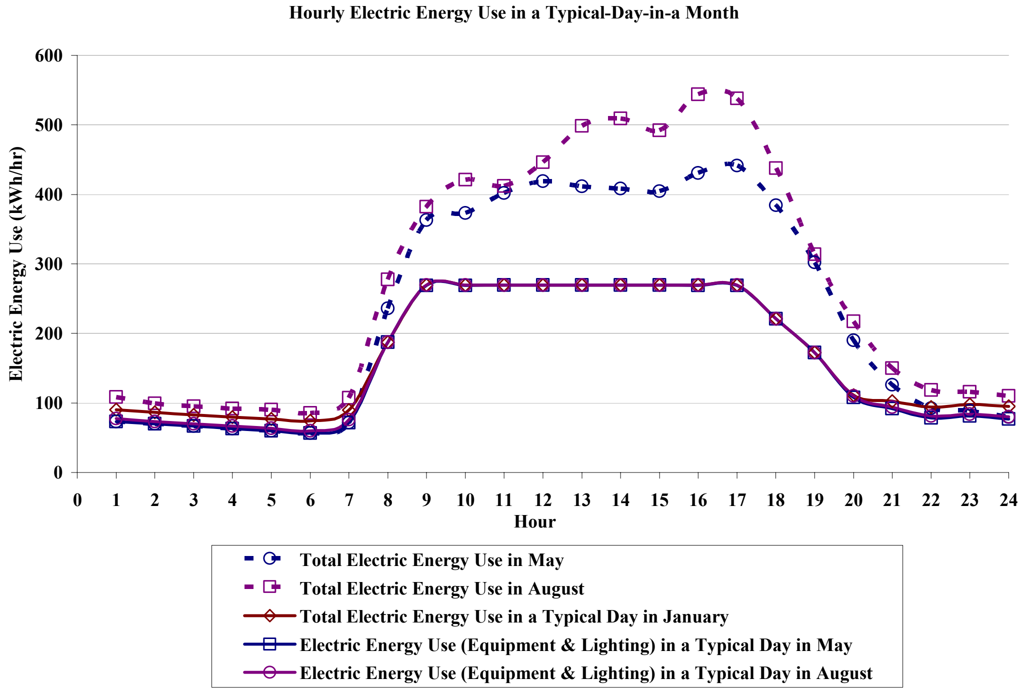

Figure 18: Hourly Electric Energy Use during a Typical Day in a Month by the Building.

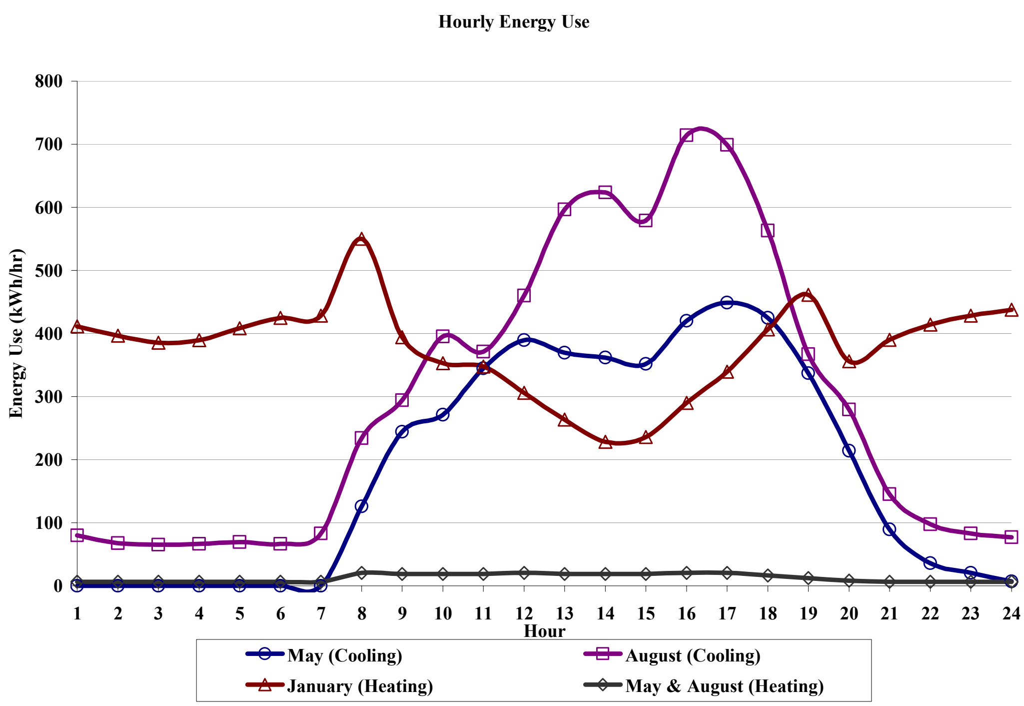

Figure 19: Hourly Energy Use during a Typical Day in a Month by the Building.

3.3 System Energy Production

Onsite cogeneration processes examined in this study were a solid oxide fuel cell (SOFC), a microturbine, a 3-MW internal combustion engine (ICE), and a 143-kW internal combustion engine (ICE). When the cogeneration processes were operated to meet the electrical load, i.e., electrical load following, they produced heat, which could be used to satisfy some of the building's thermal demand. On the other hand, when the cogeneration processes were operated to meet the thermal load of the building, i.e., thermal load following, they produced electricity, which could be used to satisfy some of the electrical demand of the building. The electrical and thermal production from the cogeneration processes depend on their corresponding electrical and thermal efficiencies. Table 6 shows the electrical and thermal efficiencies of the cogeneration systems examined in this study.

Efficiency is defined as the amount of fuel input energy that is converted to useful heat and electricity etc. (Major, 1995).

Electrical efficiency is calculated by dividing the fuel input by the electrical energy output.

Thermal efficiency is calculated by dividing the fuel input by heat energy output.

Overall efficiency is the sum of electrical and thermal efficiencies.

Table 6: Electrical and Thermal Efficiencies of the Cogeneration Systems.

Cogeneration Process	Electrical Efficiency	Thermal Efficiency	Overall Efficiency
SOFC	47%	26-33%[12]	80%
Microturbine	28%	52%	80%
3-MW ICE	39%	41%	80%
143-kW ICE	29%	51%	80%

[12] Although both 26% and 33% thermal efficiencies were modeled, the results given in this study were for the SOFC with the 26% thermal efficiency.

To obtain the electrical and thermal energy produced from a cogeneration process that was operated to follow the thermal and electrical energy use of the building, respectively, a series of calculations were performed. Refer to Chapter 2 for calculation methodology.

Appendix E contains the electric energy produced from the cogeneration systems while following the thermal load of the building. Table E-21 shows the annual electric energy production; Table E-22 shows the daily electric energy production; Tables E-23, E-24, and E-25 show the electric energy production during a typical day in January, May, and August from cogeneration systems while following the thermal load of the building. Appendix F contains the thermal energy produced from the cogeneration systems while following the electric load of the building. Table F-26 shows the annual thermal energy production; Table F-27 shows the daily thermal energy production; Tables F-28, F-29, and F-30, show the thermal energy production during a typical day in January, May, and August from the cogeneration systems while following the electric load of the building.

3.3.1 Thermal Load Following (TLF)

Annual Electrical Energy Production (TLF)

Figure 20 shows the annual electric energy co-generated from the cogeneration processes while following the thermal load of the building. The thermal load of the building consisted of space and water heating, and cooling. Heat produced from a cogeneration process was used to drive a boiler for space and water heating and to drive an absorption chiller for cooling.

The electric energy generated from the cogeneration processes corresponded to their electrical efficiencies. Cogeneration processes with high electric efficiencies produced more electricity than those with lower ones. As shown in Figure 20, The SOFC co-generated the highest electrical energy followed by the 3-MW ICE, the 143-kW ICE and finally the microturbine; their respective electrical efficiencies are: 47%, 39%, 29%, and 28%.

As shown in Figure 20, the SOFC produced twice as much electricity as the building's load. Both the microturbine and the 143-kW ICE produced less electrical energy than required by the building because of their low electrical efficiencies (28% and 29%, respectively), whereas, the 3-MW ICE met the electrical load of the building. On the other hand, if conventional systems were used to meet the electric energy use of the building including cooling, 1.7E+06 kWh of electric energy would be required (not including space and water heating).

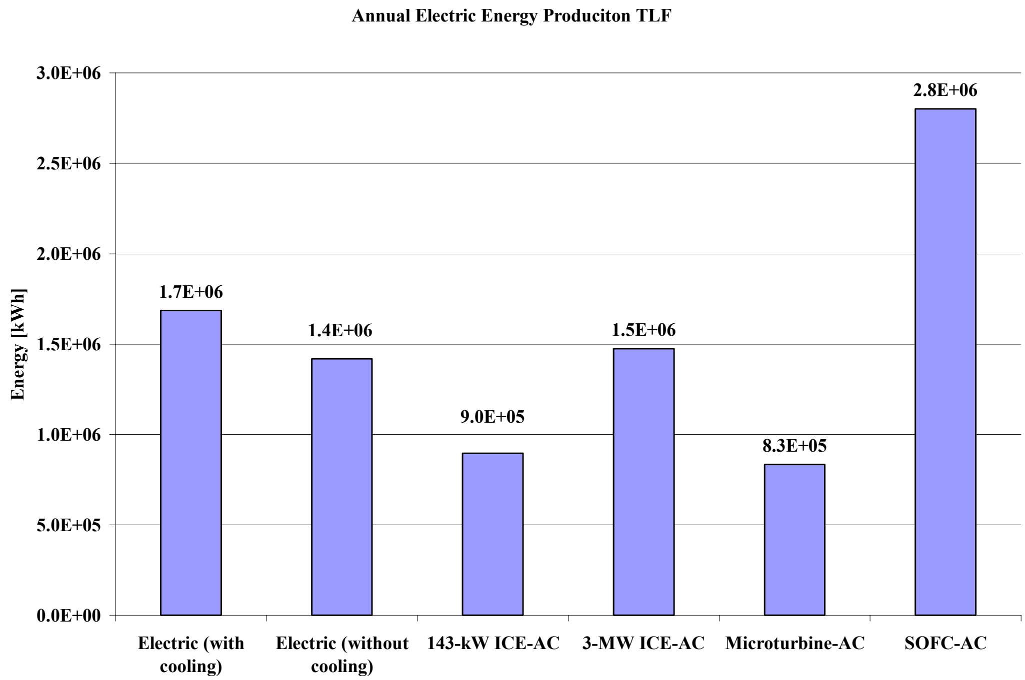

Figure 20: Annual Electric Energy Production from Cogeneration Systems using Absorption Chillers for Cooling (TLF).

Daily and Hourly Electrical Energy Production (TLF)

Figure 21 and Figure 22 show the daily and hourly thermal energy generated from the cogeneration processes, respectively. The electric energy use of the building consisted mainly of equipment and lighting. In January the thermal load of the building consisted mainly of space and water heating. In May and August the thermal load of the building consisted of mainly of water heating and cooling. In January, heat from a cogeneration process was used to meet the thermal energy use of the building. In May and August, heat from a cogeneration process was used for space and water heating and to drive an absorption chiller for cooling.

In January, for the thermal load following scenario, all processes produced more electrical energy than the demand. In a typical day, January had the highest power production from all processes as compared to May and August because of the high thermal demand. Power production from the cogeneration processes followed their electrical efficiencies. SOFC produced more power than the 3-MW ICE followed by 143-kW ICE and the microturbine; their respective electrical efficiencies were 47%, 39%, 29%, and 28%. As shown in Figure 21, in January, the SOFC produced about 75% more electrical energy than the demand. The 3-MW ICE produced approximately twice as much power as required while both the 143-kW ICE and the microturbine produced approximately equal electricity to the demand.

In January, the hourly electrical energy production over a day followed the thermal demand profile for all processes. As shown in Figure 22, while following the thermal load, at the beginning and the end of the day all processes produced more electricity than the demand; however, during working hours (hours 9-18), the 143-kW ICE and the microturbine, as well as the 3-MW ICE at hours 13-16, failed to meet the electric demand and, hence, needed supplemental electricity from the grid.

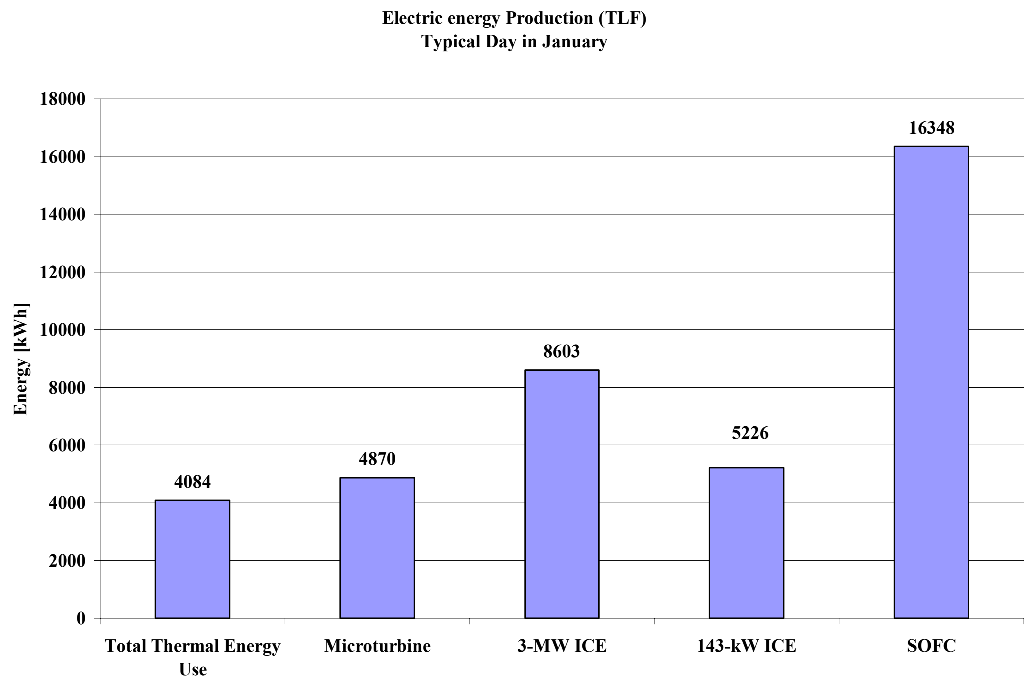

Figure 21: Electrical Energy Production from Cogeneration Processes for a Typical Day in January (TLF) {9044 kWh}.

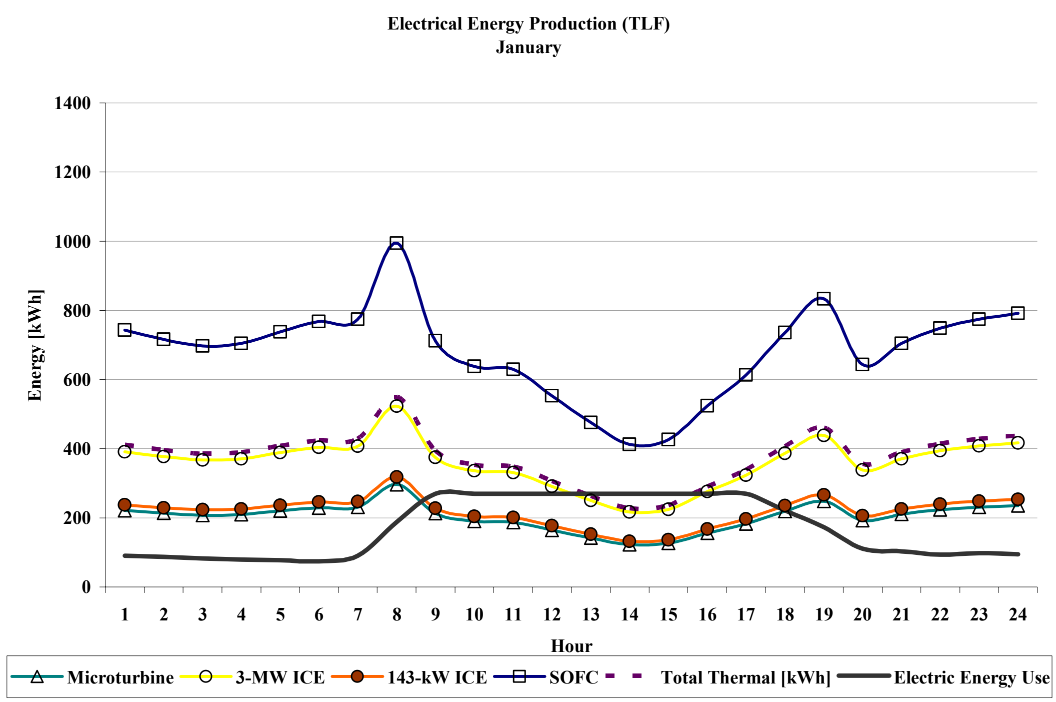

Figure 22: Hourly Electrical Energy Production from Cogeneration Processes during a Typical Day in January (TLF).

As in January, power production from the cogeneration processes in May followed their electric efficiencies; however, the resulting power from the processes was much lower in May because of the lower thermal demand of the building (302 kWh) as compared to January (9044 kWh).

In a typical day in May, while the electric demand decreased slightly from January, the thermal demand was much less and, consequently, some of the cogeneration processes were not able to meet the electric demand of the building while following the thermal load. For instance, as shown in Figure 23, the microturbine and the 143-kW ICE needed supplemental electricity to meet the electric demand of the building; whereas, the SOFC produced twice the electricity demanded and the 3-MW ICE produced approximately equal electricity to the demand.

As shown in Figure 24, while following the thermal load, all cogeneration processes produced less electricity than that required at the beginning and end of the day in May; however, during some of the working hours, the SOFC and the 3-MW ICE produced more power than required while the microturbine and the 143-kW ICE continued to produce less power than the demand.

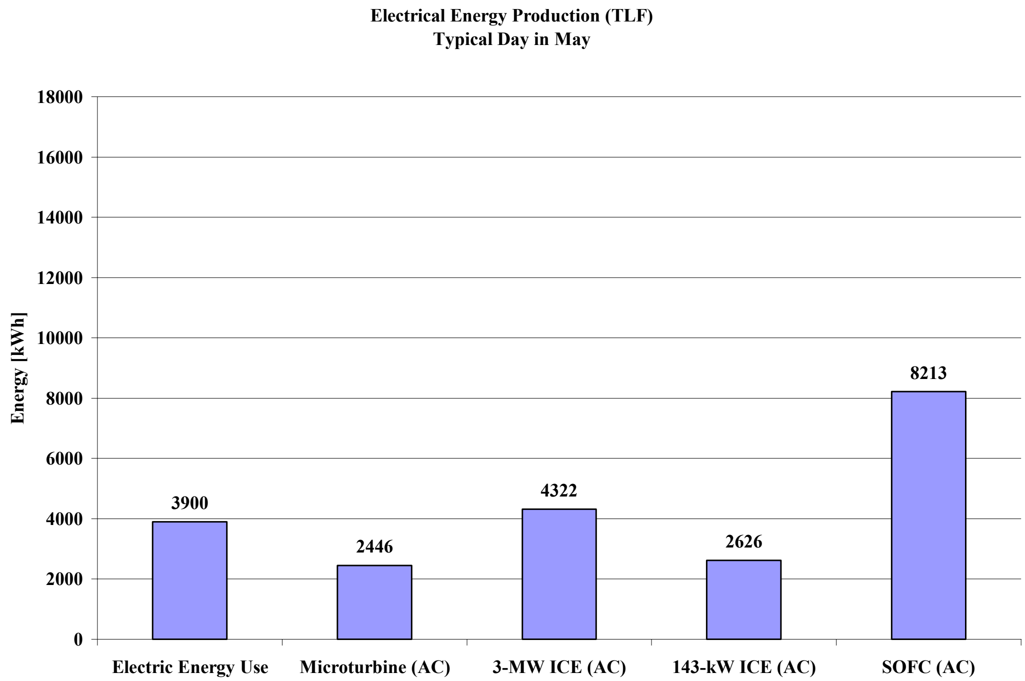

Figure 23: Electrical Energy Production from cogeneration Processes for a Typical Day in May (TLF) {302 kWh}.

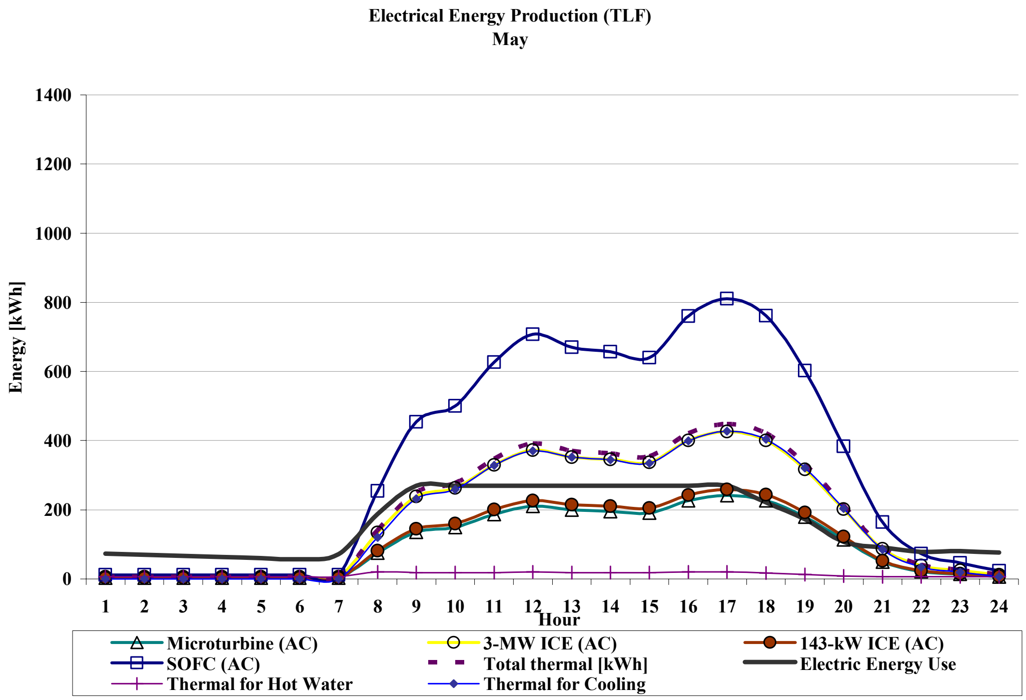

Figure 24: Hourly Electrical Energy Production from Cogeneration Processes during a Typical Day in May (TLF).

In a typical day in August, the electric demand of the building was approximately equal to that in May; however, the thermal demand was more than in May and, hence, the cogeneration processes produced more electricity than in May while following the thermal load. As shown in Figure 25, the microturbine and the 143-kW ICE produced electricity approximately equal to the demand while the 3-MW ICE produced almost twice as much power as required and SOFC produced about 70% more electricity than required.

The hourly power production from the cogeneration processes in August was slightly different than in May, (where all units produced less electricity than that required at the beginning and end of the day). As shown in Figure 26, in August the SOFC produced more electricity than the demand in early and late night hours while the other cogeneration processes remained in need of supplemental power. In addition, during the working hours, the microturbine and the 143-kW ICE, unlike in May, produced more electricity than the demand.

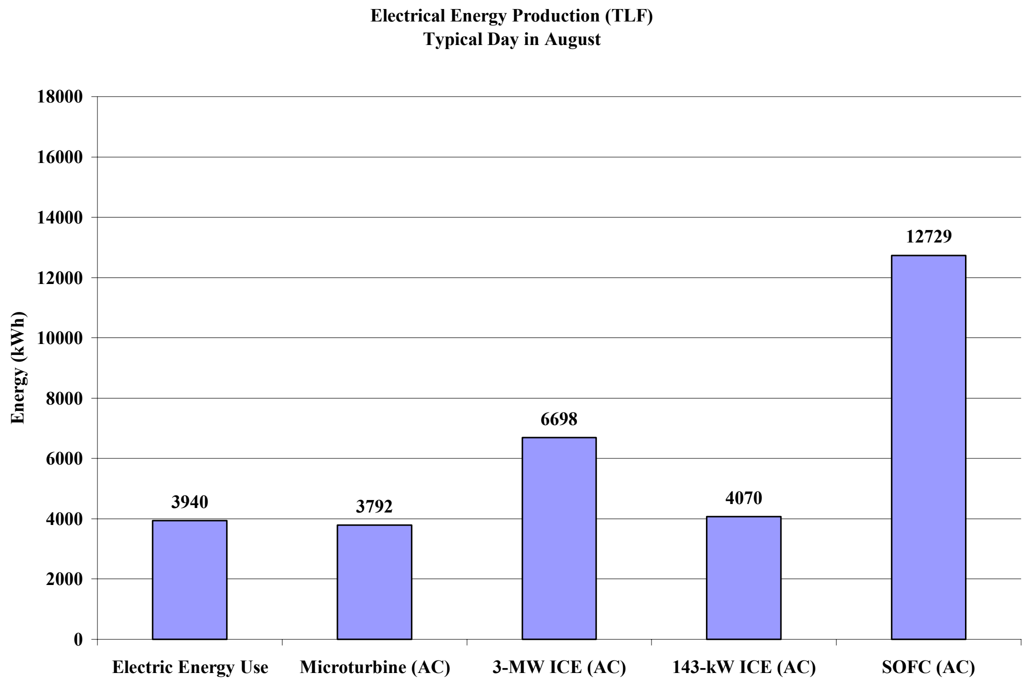

Figure 25: Electrical Energy Production for a Typical Day in August (TLF) {302 kWh}.

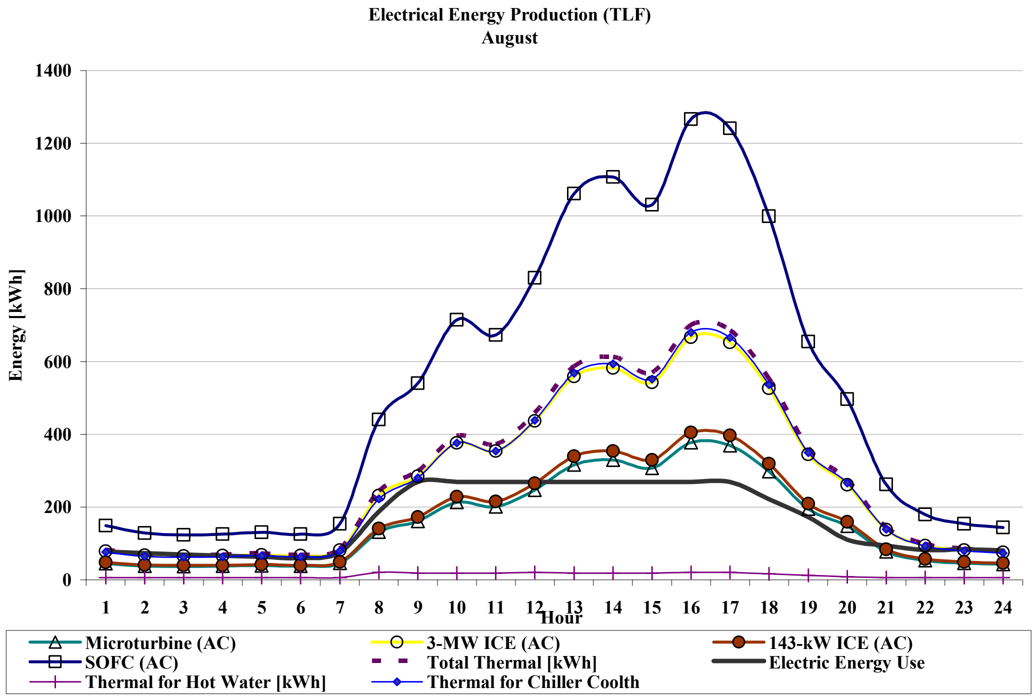

Figure 26: Hourly Electrical Energy Production from Cogeneration Processes during a Typical Day in August (TLF).

3.3.2 Electric Load Following (ELF)

Annual Thermal Energy Production (ELF)

Figure 27 shows the annual thermal energy co-generated from the cogeneration processes while following the electric load of the building. Electric energy generated from a cogeneration process was used to meet the electric load of the building. Two options were investigated for cooling: absorption chillers and electric chillers. In the first option, a cogeneration process was operated to follow the electric energy use of the building consisting of equipment and lighting only and the co-generated heat was used to meet part or all of the heating demand and also to drive an absorption chiller (AC) for cooling. In the second case, a cogeneration process was operated to follow the electric energy use of the building including equipment, lighting, and cooling using an electric chiller (EC). The co-generated heat in the second case was used to meet part or all of the heating demand of the building.

As shown in Figure 27, cogeneration processes with AC produced less heat than with EC. The thermal energy generated from the cogeneration processes corresponded to their respective thermal efficiencies; cogeneration processes with high thermal efficiencies produced more heat than those with lower ones. As shown in Figure 27, the microturbine co-generated the highest thermal energy followed by the 143-kW ICE, the 3-MW ICE and finally the SOFC; their respective thermal efficiencies were: 52%, 51%, 41%, and 26%.

All cogeneration systems except the SOFC with AC were able to meet the space and water heating energy use of the building.

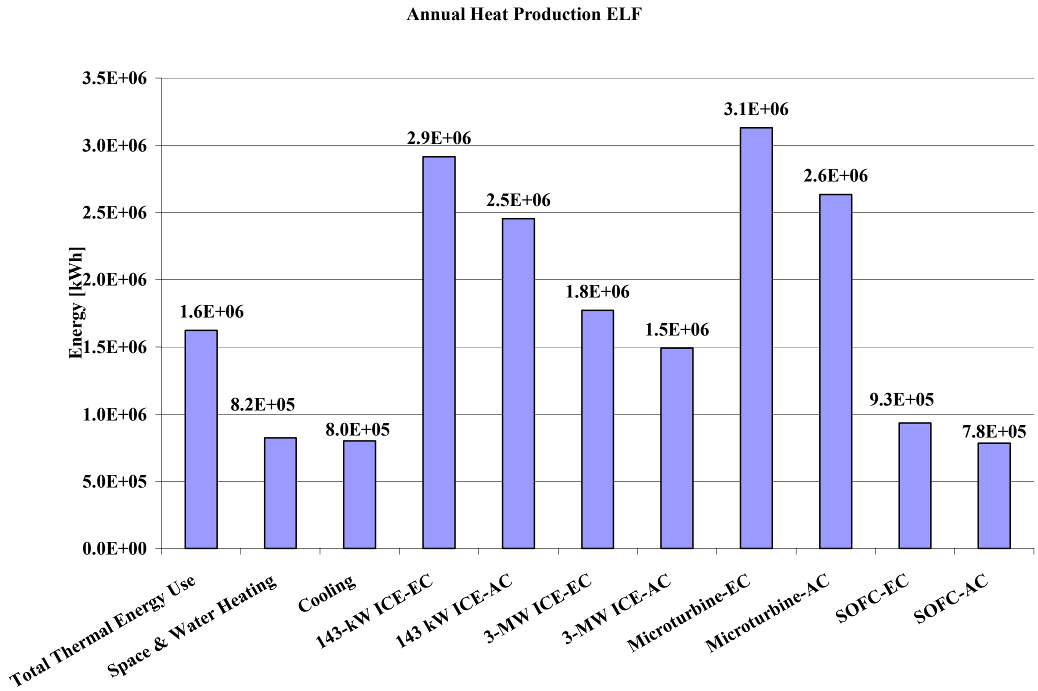

Figure 27: Annual Heat Energy Produced from Cogeneration Processes (ELF).

Daily and Hourly Thermal Energy Production (ELF)

In January the electric load of the building consisted mainly of office equipment and lighting. In May and August the electric load of the building consisted of office equipment, lighting, and cooling. In January, electric energy from a cogeneration process was used meet the electric load. In May and August, electric energy from a cogeneration process was also used to also meet the electric load; however, two options for cooling were considered: one using electric chiller only and the other using a combination of electric and absorption chillers (where the otherwise wasted heat from the cogeneration process was used to run the absorption chiller).

In a typical day in January, while satisfying the electrical load (equipment and lighting), all cogeneration processes required supplemental heat to meet the thermal demand of the building. Heat production from the cogeneration processes followed their respective thermal efficiencies; the microturbine produced more heat than the 143-kW ICE followed by the 3-MW ICE and finally the SOFC; their respective thermal efficiencies were 52%, 51%, 41%, and 26%. As shown in Figure 28, in January, the SOFC supplied about 25% of the daily thermal demand of the building. The 3-MW ICE produced approximately 50% of the demand while both the 143-kW ICE and the microturbine produced approximately 80% of the demand.

In January, the hourly heat production over a typical day followed the electric demand profile for all processes. As shown in Figure 29, in January while following the electrical load, at the beginning of the day (hours 1-6), all cogeneration processes produced low quantities of heat which corresponded to the low electric demand. Most of the heat demand at those hours was satisfied by a gas boiler. Heat production begun to increase between hours 6-9 with the increase in the electric demand, and became constant during the working hours (9-17) because of the constant electric demand. Heat production decreased between hours 17-20 and then became approximately constant throughout the night hours (20-24) when there was low electric demand. The gas boiler was used to meet the thermal demand during these hours. As shown in Figure 29, peak thermal demand occurs at hour 8 and 18 of the day. All cogeneration processes required external heat to meet the thermal demand except the microturbine and the 143-kW ICE during the working hours, and the 3-MW ICE at hours 13-16 when they produced more thermal energy than required.

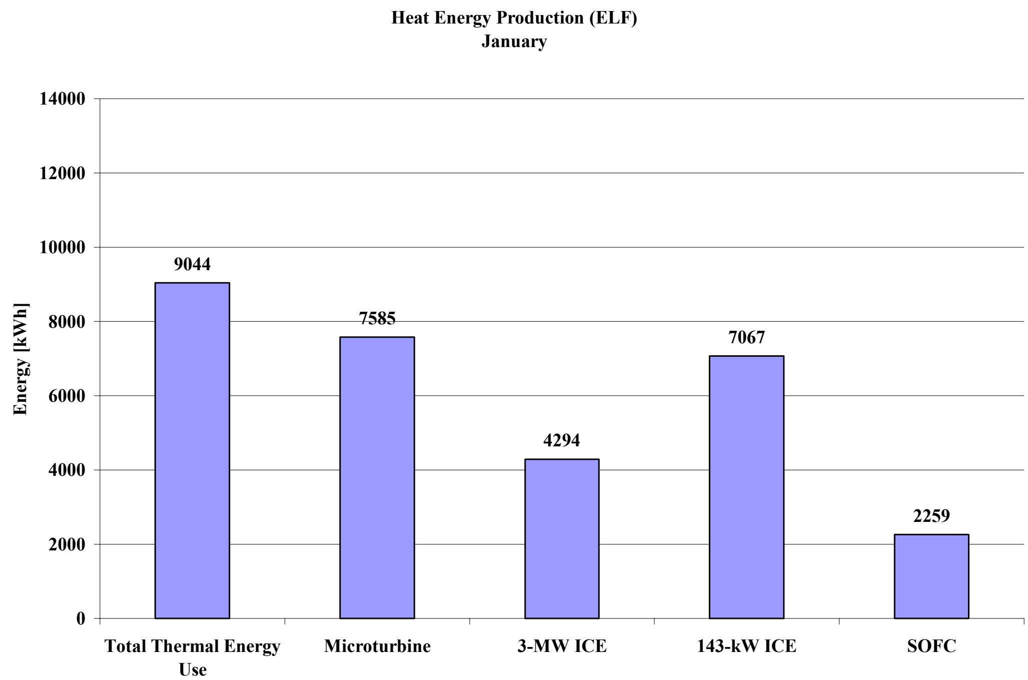

Figure 28: Heat Production from Cogeneration Processes for a Typical Day in January (ELF) {4084}.

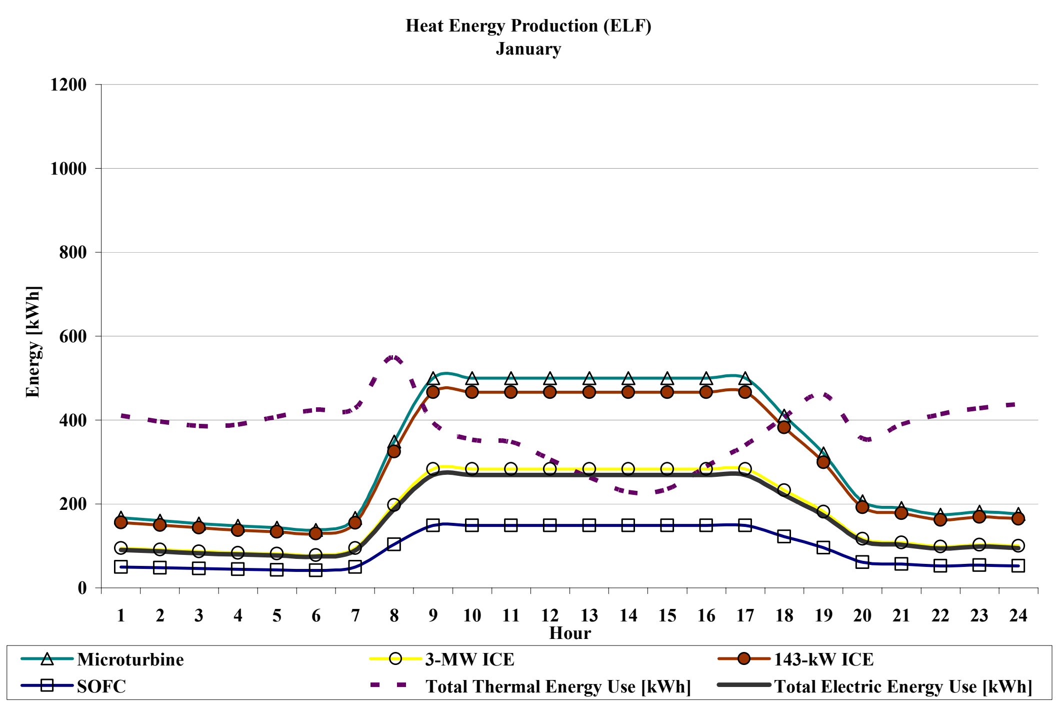

Figure 29: Hourly Heat Production from Cogeneration Processes during a Typical Day in January (ELF).

Similar to January, in a typical day in May, the heat production from the cogeneration processes followed their thermal efficiencies. For instance, as shown in Figure 30, for both cogeneration systems using EC or AC/EC for cooling, the microturbine and the 143-kW ICE had the highest heat production followed by the 3-MW ICE and the SOFC. In May and August, as the thermal demand decreased significantly from January, all cogeneration processes (with EC as well as AC/EC) produced more heat than required by the building. In May and August the heat demand was low, consisting mostly of domestic hot water. However, in May and August, as cogeneration processes using AC/EC had to generated enough thermal energy to meet the cooling demand (as part of the thermal energy was used to drive the AC), not all cogeneration processes were able to generate sufficient thermal energy to meet the cooling demand.

In May, as shown in Figure 30, the 3-MW ICE (AC/EC) and the SOFC (AC/EC) generated less thermal energy than the cooling demand, whereas, the microturbine (AC/EC) and the 143-kW ICE (AC/EC) generated more thermal energy than the cooling demand.

As shown in Figure 31, in May, during all hours of the day, while following the electric load, all cogeneration processes with EC as well as AC/EC produced more heat than the heating requirement of the building. At the beginning of the day (hours 1-6), heat production from the cogeneration processes was low following the electric load, then it begun to increase dramatically between hours (6-9) with the increase in electric demand, and continued to increase gradually during the working hours (9-17) because of the relatively constant electric demand. By the end of the day (hours 17-20), heat production decreased and then became approximately constant throughout the night hours (20-24) when there was low electric demand. The peak thermal demand occurred at hours 8 and 17.

As shown in Figure 31, the 3-MW ICE (AC/EC) and the SOFC (AC/EC) were not able to meet the thermal requirement for cooling for most of the day, whereas, the microturbine (AC/EC) and the 143-kW ICE (AC/EC) were able to meet the thermal demand for cooling at all hours.

As shown in Figure 32 and 33, August was similar to May, but more heat was produced from the cogeneration processes with the increase in the electrical demand.

As shown in Figure 32, unlike May, in August, the 143-kW ICE (AC/EC) was not able to generated sufficient thermal energy to meet the cooling demand but the microturbine (AC/EC) was able to meet the thermal requirement for cooling. Similar to May, both the 3-MW ICE (AC/EC) and the SOFC (AC/EC) were not able to meet the thermal requirement for cooling.

As shown in Figure 33, unlike in May, in August, the microturbine (AC/EC) and the 143-kW ICE (AC/EC) were not able to meet the thermal requirement for cooling during peak hours (hours 13-18) but were able to meet the cooling demand for the rest of the day. Similar to May, in August, the 3-MW ICE (AC/EC) and the SOFC (AC/EC) were not able to meet the thermal requirement for cooling at all hours of the day.

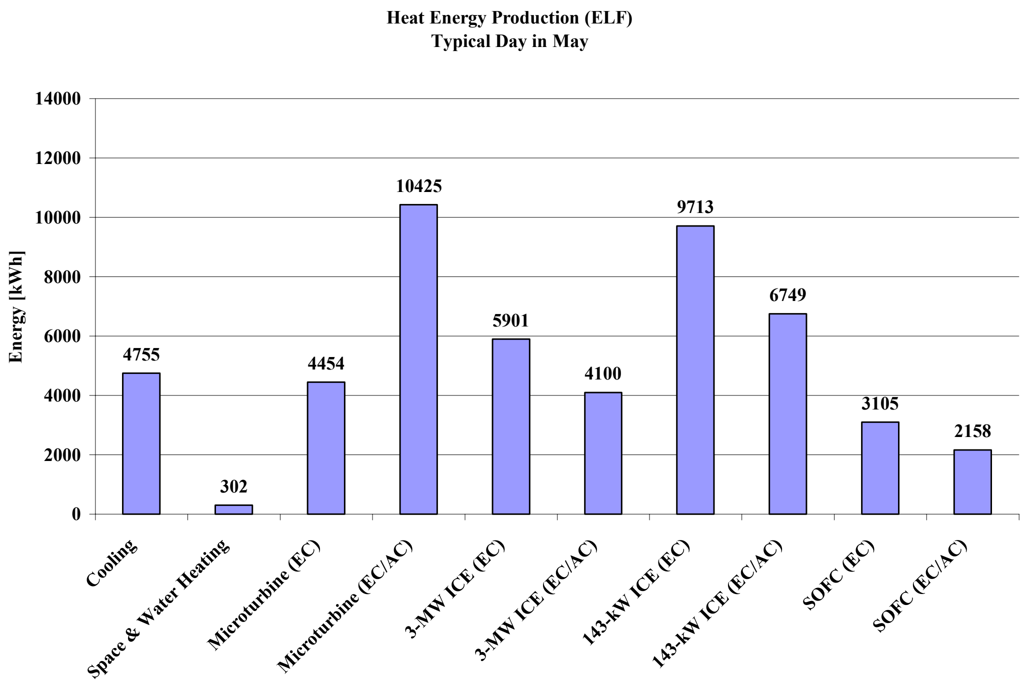

Figure 30: Heat Production from Cogeneration Processes for a Typical Day in May (ELF) {5613 kWh}.

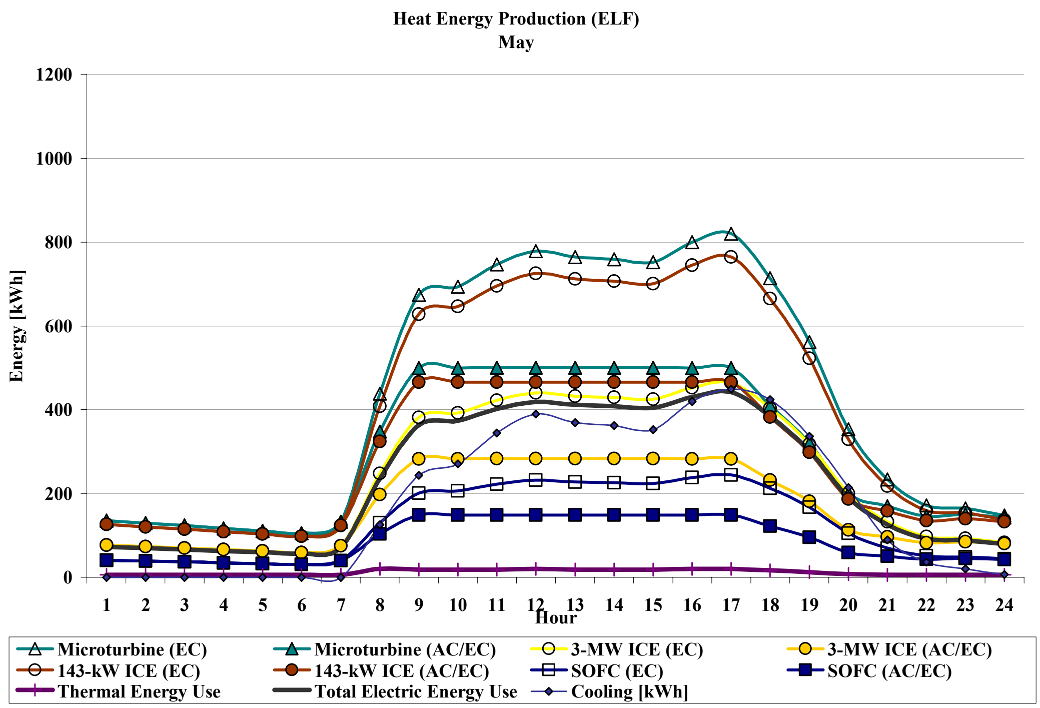

Figure 31: Hourly Heat Production from Cogeneration Processes during a Typical Day in May (ELF).

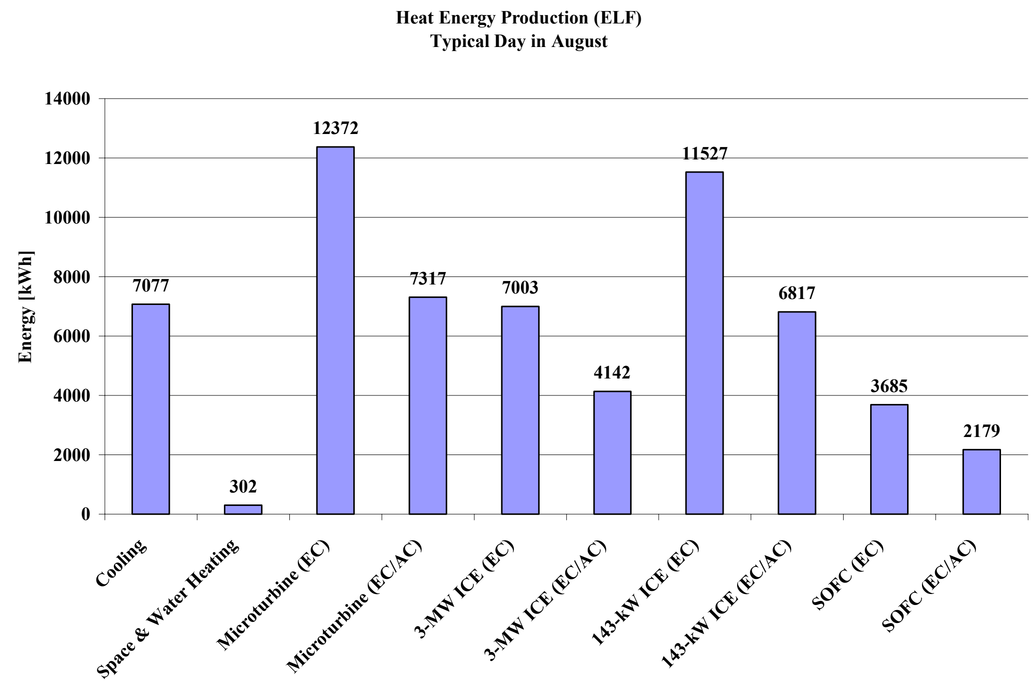

Figure 32: Heat Production from Cogeneration Processes for a Typical Day in August (ELF) {6662 kWh}.

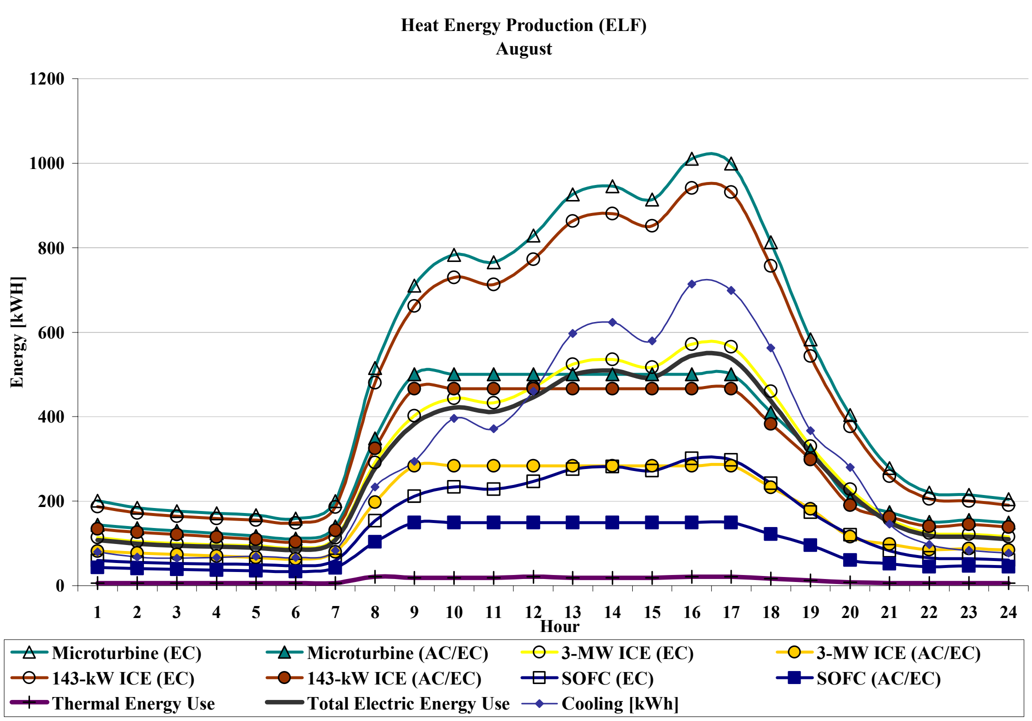

Figure 33: Hourly Heat Production from Cogeneration Processes during a Typical Day in August (ELF).

4.0 ENVIRONMENTAL IMPACT ANALYSIS OF ENERGY USE IN BUILDING (TLF)

This Chapter includes analysis of the results obtained by creating different scenarios for energy systems and operational strategies in the LCA software. As explained in previous chapters, cogeneration systems are used to provide electrical and thermal energy for the hypothetical building and compared to conventional systems (electric generation mix and NGCC). Refer to Table 4 in Chapter 2 for a summary of the strategies analyzed in the model.

The environmental impact resulting from the construction and operation of energy systems to provide electrical and thermal energy for the building are analyzed in annual, daily, and hourly basis. Three months are chosen for the daily and hourly analysis: January, May, and August. Four environmental impact indicators are chosen for the analysis: primary energy consumption, global warming potential (GWP), tropospheric ozone precursor potential (TOPP), and acidification potential (AP).

In this chapter, the cogeneration processes were operated to follow the thermal load of the building, consisting of space and water heating, and cooling which was met by absorption chillers, and their primary energy consumption and emissions are compared to that from average electric generation mix and natural gas combined cycle. Average electric mix and NGCC met the electric energy use of the building including cooling with electric chillers and met the heating energy use with gas boilers.

The chapter contains the following sections:

Section 4.1: Primary Energy Consumption (TLF)

Section 4.1.1: Annual Primary Energy Consumption Analysis (TLF)

Section 4.1.2: Typical Day in a Month Primary Energy Consumption Analysis (TLF)

Section 4.1.3: Hourly Primary Energy Consumption in a Typical Day in a Month Analysis (TLF)

Section 4.2: Global Warming Potential (GWP) (TLF)

Section 4.2.1: Annual GWP Analysis (TLF)

Section 4.2.2: Typical Day in a Month GWP Analysis (TLF)

Section 4.2.3: Hourly GWP in a Typical Day in a Month Analysis (TLF)

Section 4.3: Tropospheric Ozone Precursor Potential (TOPP) (TLF)

Section 4.3.1: Annual TOPP Analysis (TLF)

Section 4.3.2: Typical Day in a Month TOPP Analysis (TLF)

Section 4.3.3: Hourly TOPP in a Typical Day in a Month Analysis (TLF)

Section 4.4: Acidification Potential (AP) (TLF)

Section 4.4.1: Annual AP Analysis (TLF)

Section 4.4.2: Typical Day in a Month AP Analysis (TLF)

Section 4.4.3: Hourly AP in a Typical Day in a Month Analysis (TLF)

Section 4.5: Summary of Results (TLF)

The section provides a summary of the environmental impact indicators used in the study and includes normalized curves of the environmental indicators studied for a typical day in a month used to present comparisons between the energy systems analyzed. The normalized curves are given in the following sub-sections:

Section 4.5.1: Normalized Curves for Single Environmental Indicators in all Months (TLF)

Results from each environmental indicator are normalized for a typical day in January, May, and August to compare the performances of all the energy systems examined.

Section 4.5.2: Normalized Curves for All Environmental Indicators in Each Month (TLF)

Results from all environmental indicators are normalized in one graph for each typical day in January, May, and August to compare the performances of all the energy systems examined.

Section 4.5.3: Summary (TLF)

The section provides a summary of the results in the chapter.

The calculations performed in order to obtain data for the model are given in Chapter 2.

Note that the energy systems referred to in this chapter, (the average electric mix, NGCC, SOFC, microturbine, 143-kW ICE, and 3-MW ICE) are groups of linked processes used to meet the thermal and electric load of the building. For example, a 'microturbine' could be the cogeneration process in addition to a chiller, a boiler, supplemental electricity from average electric mix, resource extraction, transportation etc. A breakdown of the processes used to construct the scenarios, including tables of data inputted into the software, is given in Appendix G. The basic process trees used in the model are given in Appendix J.

Tables of primary energy consumption and emissions from the energy generation systems studied (output from GEMIS) are given in Appendix H.

4.1 Primary Energy Consumption (TLF)

4.1.1 Annual Primary Energy Consumption Analysis (TLF)

Both the NGCC and the average electric mix systems generated electricity to meet cooling energy use (electric chiller) and electric energy use of the building, and used gas boilers to meet the space and water heating. In another option, NGCC and the average electric mix met the cooling using absorption chillers driven by heat from gas boilers. On the other hand, the cogeneration processes generated thermal energy to meet the cooling energy use (absorption chiller), and the space and water heating (gas boilers), while the co-generated electric energy was used to meet part or all of the electrical load (office equipment, lighting, and ventilation).

While following the thermal load of the building, the primary energy consumption by the cogeneration processes, corresponded to their thermal efficiencies except for the microturbine and the 143-ICE. Processes with high thermal efficiencies consumed less energy than those with lower ones. Although the microturbine and 143-kW ICE had high thermal efficiencies, 52% and 51% respectively, their energy consumption was higher than the 3-MW ICE, whose thermal efficiency was 41%, as shown in Figure 34. This was because both the microturbine and the 143-kW ICE had lower electrical efficiencies, 28% and 29%, respectively; compared to the 3-MW-ICE whose electrical efficiency was 39%. Because of their lower electrical efficiencies, both the microturbine and the 143-kW ICE produced lower electrical energy than that required by the building, and hence required supplemental power (from the average electric mix) to meet the electric demand (office equipment, lighting, and ventilation); whereas, the 3-MW ICE produced sufficient electric energy to meet the electric energy use of the building.

The SOFC, having the lowest thermal efficiency (26%) compared to the other cogeneration processes, had the highest primary energy consumption, even higher than the NGCC and the average electric mix. However, if the thermal energy from the SOFC was used for space and water heating only, and the co-generated electricity (SOFC had relatively high electric efficiency (47%)), was used to meet part of electric energy use, (which in this case will include cooling, equipment, lighting, and ventilation), then the co-generated electricity from the SOFC would be utilized, and therefore less energy would be consumed. This particular scenario is shown in Figure 34, denoted by SOFC-EC, where the SOFC was used to meet the space and water heating, and the co-generated electricity was used to meet part of the electric load, however, some supplemental electricity (from average electric mix) was required to satisfy the electric energy use of the building.

When comparing the energy consumption by all the processes, the 3-MW ICE (AC) had the lowest annual primary energy consumption followed by the NGCC (EC), which had approximately similar energy consumption to the microturbine (AC) and the 143-kW ICE (AC), followed by the average electric mix (EC) and finally the SOFC (AC).

The difference between the use of absorption chiller (AC) and electric chiller (EC) is illustrated in Figure 34, where the use of AC for cooling with the average electric mix or NGCC resulted in higher primary energy consumption than in the case of EC. This was mainly because the AC had lower coefficient of performance (COP) than the EC, 1.05 and 4.6, respectively.

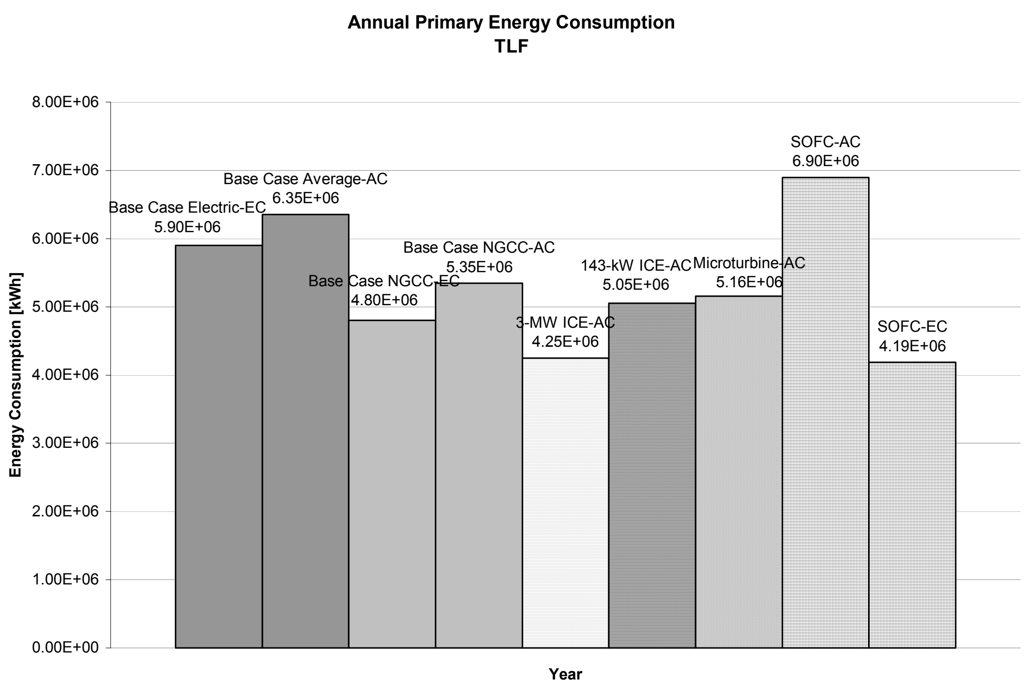

Figure 34: Annual Primary Energy Consumption (TLF).

4.1.2 Typical Day in a Month Primary Energy Consumption Analysis (TLF)

January

In January, there was no cooling load and the cogeneration systems were operated to meet the space and water heating energy use of the building and the co-generated electricity was used to meet the electric load of the building. As electric storage was assumed over the day, all cogeneration systems were able to meet the electric demand of the building. Average electric generation mix and NGCC were used in two options to meet the electric energy use of the building, and gas boilers to meet the heating load.

While following the thermal load of the building, the primary energy consumption by all cogeneration processes corresponded to their respective thermal efficiencies. The process with the lowest efficiency had the highest energy consumption: the SOFC had more energy consumption than the 3–MW ICE followed by the 143-kW ICE and finally the microturbine. As shown in Figure 35, the SOFC had the highest energy consumption, approximately twice as much as the energy consumed by the other cogeneration processes and also approximately twice as much as the energy consumed by the average electric generation mix and the NGCC. All the cogeneration processes except the SOFC had comparable energy use to those from the average electric generation mix and the NGCC.

May

In May, as well as August, the cogeneration systems were operated to meet the space and water heating and cooling energy use (with absorption chillers) of the building and the co-generated electricity was used to meet part or all of the electric load of the building. When supplemental electricity was required to meet the electric energy use of the building, it was met by electricity from the grid generated from average electric generation mix. Similar to January, average electric generation mix and NGCC were used in two options to meet the electric energy use of the building, including cooling with electric chillers, and gas boilers to meet the heating load.

As shown in Figure 36, in May, while following the thermal load, generally all the processes had comparable primary energy consumption. The 3-MW ICE (AC) had the lowest energy consumption although it had less thermal efficiency than both the 143-kW ICE (AC) and the microturbine (AC). The reason was because the 3-MW ICE had higher electrical efficiency than both the 143-kW ICE and the microturbine and produced slightly higher electricity than that required by the building while the latter two cogeneration processes, having less electrical efficiency, required some supplemental electricity to meet the electric energy use of the building.

Unlike in January where the energy consumption of the SOFC was much higher than the other processes, in May, the SOFC had slightly higher but comparable energy consumption to the other processes. The main reason was that the heating energy use of the building in January was satisfied by the gas boiler (run by heat from the cogeneration process) which had 89% thermal efficiency while in May the cooling energy use of the building was satisfied by the absorption chiller (run by heat from the cogeneration process) which had 105% thermal efficiency. Hence, the energy conversion was more efficient when using the absorption chiller than the gas boiler resulting in less primary energy consumption. However, the SOFC still remained the highest energy consuming process compared to the other cogeneration processes because of its relatively lower thermal efficiency.

All cogeneration processes except the SOFC (AC) had similar primary energy consumption to the NGCC (EC), which had lower primary energy consumption than the average electric mix (EC).

August

As shown in Figure 37, in August, while following the thermal load of the building, the SOFC (AC) had the highest primary energy consumption followed by the average electric (EC), the NGCC (EC), which had approximately equal energy consumption as the 3-MW ICE, and the microturbine, which had approximately equal energy consumption as the 143-kW ICE.

As the cooling energy use increased from May to August while the electric energy and heating energy use remained almost the constant, both the microturbine and the 143-kW ICE consumed less energy than the 3-MW ICE (unlike May) because of their higher thermal efficiency ratios compared to the 3-MW ICE allowing them to co-generate more electricity and hence were able to satisfy the electric energy use of the building (although the microturbine required a slight amount of supplemental electricity).

This indicated that when the cogeneration processes followed the thermal load, the higher the thermal load and the more thermal efficiency the process had, the more efficient the cogeneration process operated, i.e., they were be able to produce a sufficient amount of electricity without the need for supplemental electricity to meet the electric energy use of the building. However, if the thermal load was relatively low and the electric energy use was high, then the electrical efficiency in the cogeneration process was an important factor as well, in determining the overall efficiency of the cogeneration application (as was the case in May with the 3-MW ICE versus the microturbine and the 143-kW ICE).

Unlike in May, in August, with the increase in cooling energy use of the building, the SOFC consumed much higher primary energy than the other processes (approximately twice as much) because of its relatively lower thermal efficiency.

Similar to May, in August, the NGCC (EC) had lower primary energy consumption to the average electric mix (EC), whereas, the 3-MW ICE (AC) had similar primary energy consumption to the average electric mix. The 143-kW ICE (AC) and the microturbine (AC) had lower primary energy consumption than both the NGCC and the average electric mix, whereas, the SOFC (AC) had the highest primary energy consumption compared to all processes.

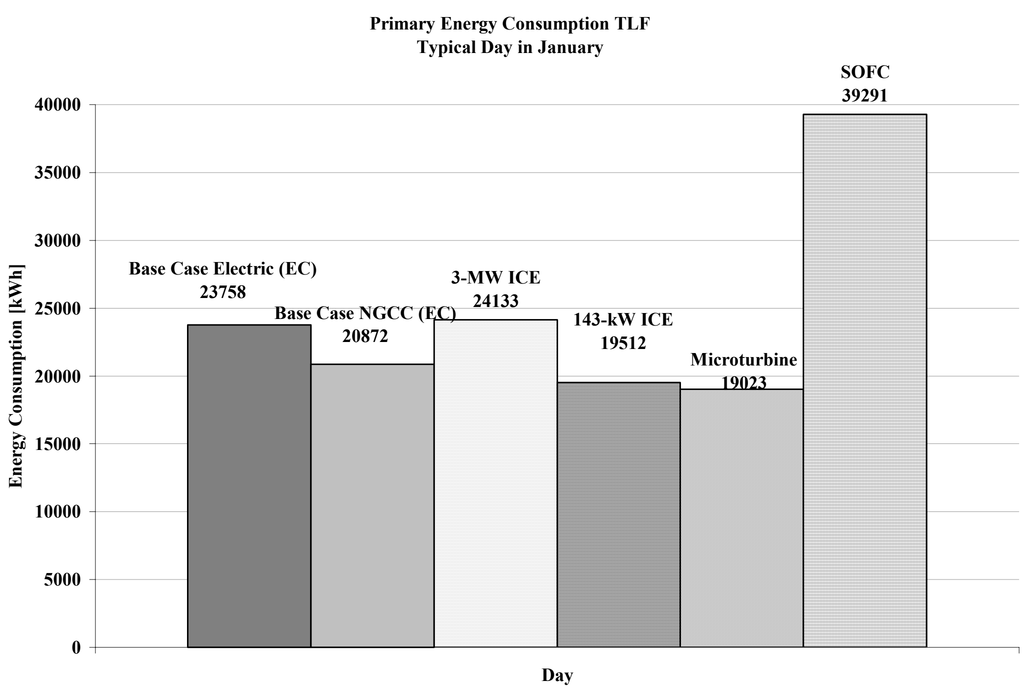

Figure 35: Primary Energy Consumption in a Typical Day in January (TLF).

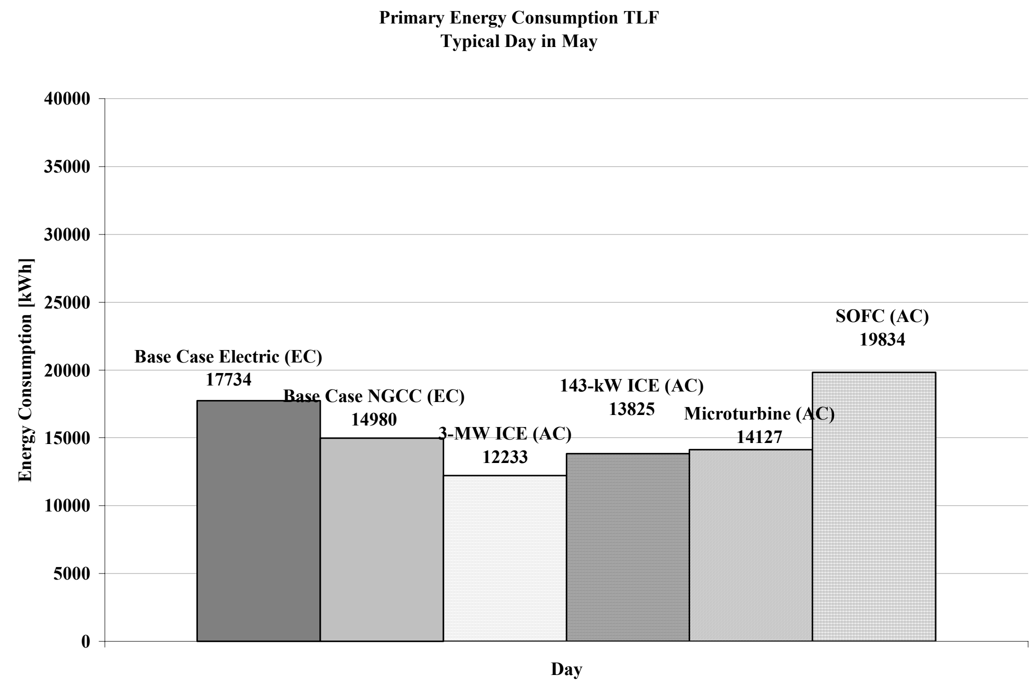

Figure 36: Primary Energy Consumption in a Typical Day in May (TLF).

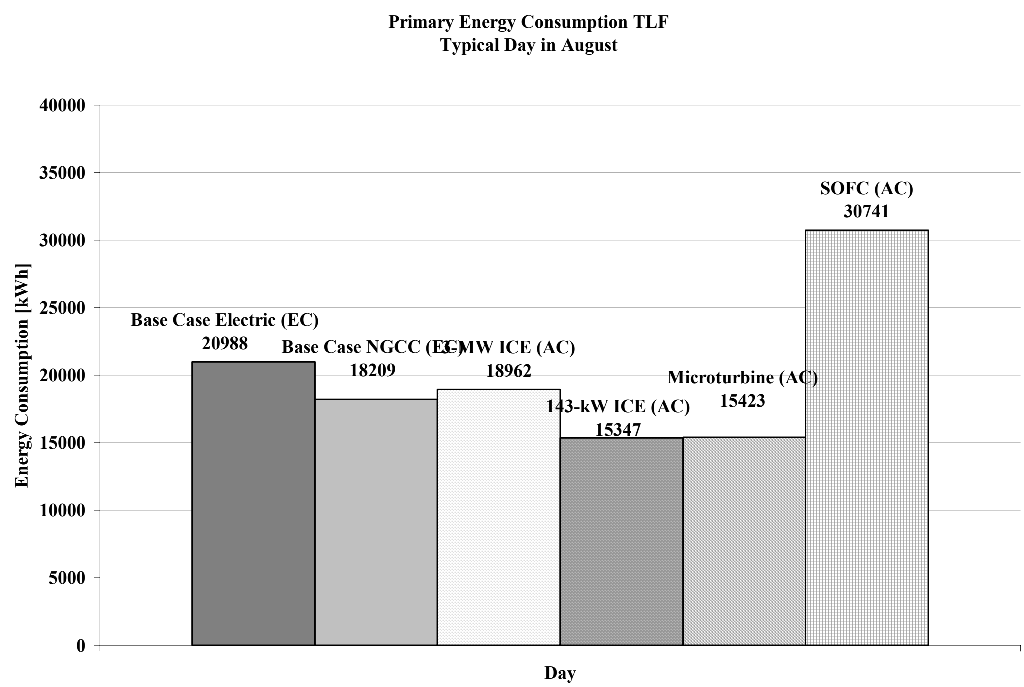

Figure 37: Primary Energy Consumption in a Typical Day in August (TLF).

4.1.3 Hourly Primary Energy Consumption Analysis (TLF)

January

For hourly scenarios, the In January, the energy systems were operated similar to the typical day in a month scenarios described in section 4.1.2. However, unlike in the typical day in a month analysis, there was no electric storage over the day assumed in the hourly scenarios and electricity from the grid (generated from average electric generation mix) was used when the co-generated electricity from the cogeneration processes did not meet the electric energy use of the building at different hours of the day.

As shown in Figure 38, in January, primary energy consumption by all the processes followed the thermal energy use profile of the building (refer to Figure 19), with maximum primary energy consumption at hours 8 and 19 and a minimum at hour 14. However, the primary energy consumption didn't follow the thermal energy use profile at hours 13-16 where some of the cogeneration processes failed to meet the electric energy use of the building while following the thermal load (mainly heating) and required supplemental electricity.

At the beginning of the day (hours 3-7) as well as the end of the day, energy consumption by cogeneration processes corresponded to their thermal efficiencies: processes with the highest thermal efficiencies used less energy. During these hours, the NGCC followed by the average electric had the least energy consumption compared to the cogeneration systems, mainly because the electric energy use of the building was low at those hours and all the cogeneration process co-generated more electricity than required while following the thermal load of the building.

However, during the working hours of the day (hours 9-17), as the electric energy use of the building increased and the thermal use decreased, some of the cogeneration processes were not able to meet the electric energy use of the building while following the thermal load. For instance, as shown in Figure 22, the microturbine and the 143-kW ICE, although having higher thermal efficiency than the 3-MW ICE, required supplemental electricity during those hours. The 3-MW ICE had the lowest energy consumption during the working hours of the day because it was able to utilize the co-generated electric energy and met the electric energy use of the building without supplemental electricity except for a couple of hours (13-16).

The energy consumption of the SOFC followed the thermal energy use profile of the building and produced more electricity than required but because if its low thermal efficiency it had the highest energy use compared to the other processes. However, although the SOFC had the highest energy consumption over the course of the day, its energy use drops significantly in the middle of the day (hours 12-17) when the thermal energy use of the building is at minimum.

May

In May, as well as August, the cogeneration systems for hourly scenarios were operated similar to the typical day in a month scenarios explained in section 4.1.2. However, as explained earlier, no electric storage was assumed over the day in the hourly scenarios and electricity from the grid (generated from average electric generation mix) was used when the co-generated electricity from the cogeneration processes did not meet the electric energy use of the building at different hours of the day.

As shown in Figure 39, in May, energy consumption by all the processes followed the total thermal energy use profile, which included cooling of the building (refer to Figure 19) except during the hours when some of the cogeneration processes failed to meet the electric energy use of the building and required supplemental electricity, such as, during hours 9-17, when the microturbine (AC) and the 143-kW ICE (AC) failed to meet the electric energy use of the building.

At the beginning of the day (hour 3-7) as well as the end of the day, all the cogeneration processes failed to meet the electric energy use of the building while following the thermal load because the thermal energy use of the building was much lower than in January, mainly hot water. During these hours, all the processes had comparable primary energy consumption to the average electric and the NGCC.

However, during the working hours of the day (hours 9-17), as the cooling energy use and the electric energy use of the building increased (thermal energy use remains constant), the cogeneration processes were able to utilize some of the co-generated electricity to meet the electric energy use of the building while following the thermal load. As shown in Figure 39, during these hours, all the cogeneration processes, except the SOFC (AC), had comparable primary energy consumption which was lower than the NGCC (EC) and the average electric mix (EC); whereas, the SOFC had the highest energy use.

August

As shown in Figure 40, similar to May, in August, while following the thermal load, primary energy consumption by all the processes followed the thermal energy use profile of the building (refer to Figure 19) except during the hours when some of the cogeneration processes failed to meet the electric energy use of the building and required supplemental electricity, such as, during hours 9-12, when the microturbine (AC) and the 143-kW ICE (AC) failed to meet the electric energy use of the building and required supplement electricity.

In August, at the beginning of the day (hour 3-7) as well as the end of the day, all the cogeneration processes except the SOFC (AC) were not able to meet the electric energy use of the building while following the thermal load, although the cooling energy use of the building increased slightly from May. This was because the thermal energy use of the building was still too low for the cogeneration processes to efficiently co-generate usable electricity from it. During these hours, all the processes had comparable primary energy consumption to the average electric and the NGCC.

Similar to May, during the working hours of the day, as the cooling energy use and the electric energy use of the building increased (thermal energy use for domestic hot water remained constant), the cogeneration processes were able to utilize some of the co-generated electricity to meet the electric energy use of the building while following the thermal load. As shown in Figure 40, during these hours, all the cogeneration processes, except the SOFC, had comparable primary energy consumption, which was similar to the NGCC and the average electric; whereas, the SOFC had the highest energy use.

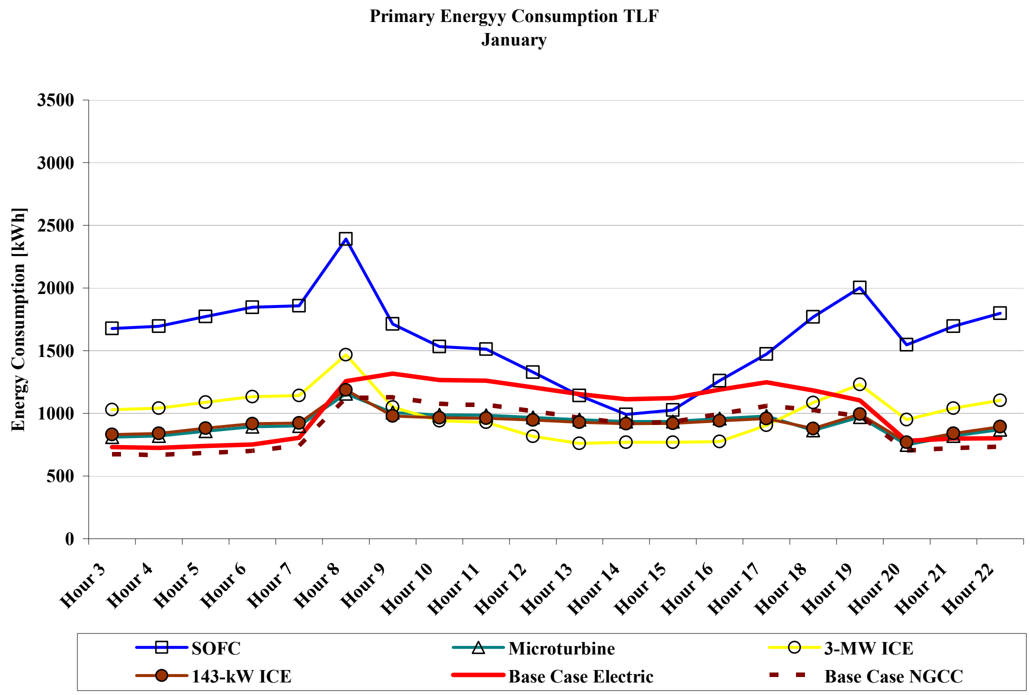

Figure 38: Primary Energy Consumption during a Typical Day in January (TLF).

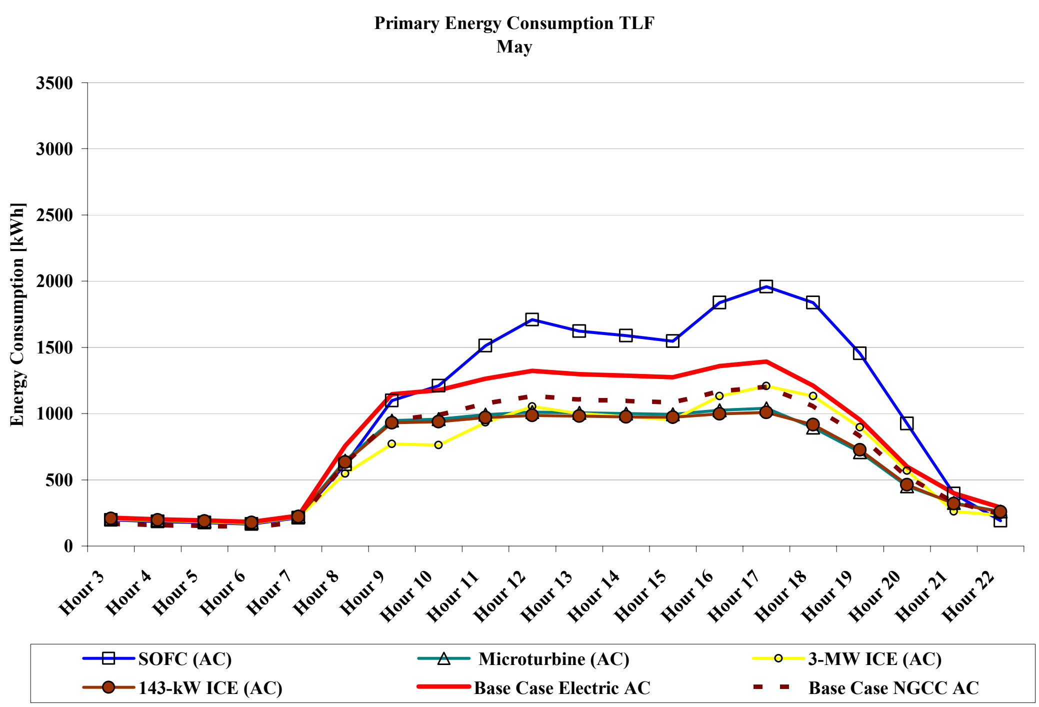

Figure 39: Primary Energy Consumption during a Typical Day in May (TLF).

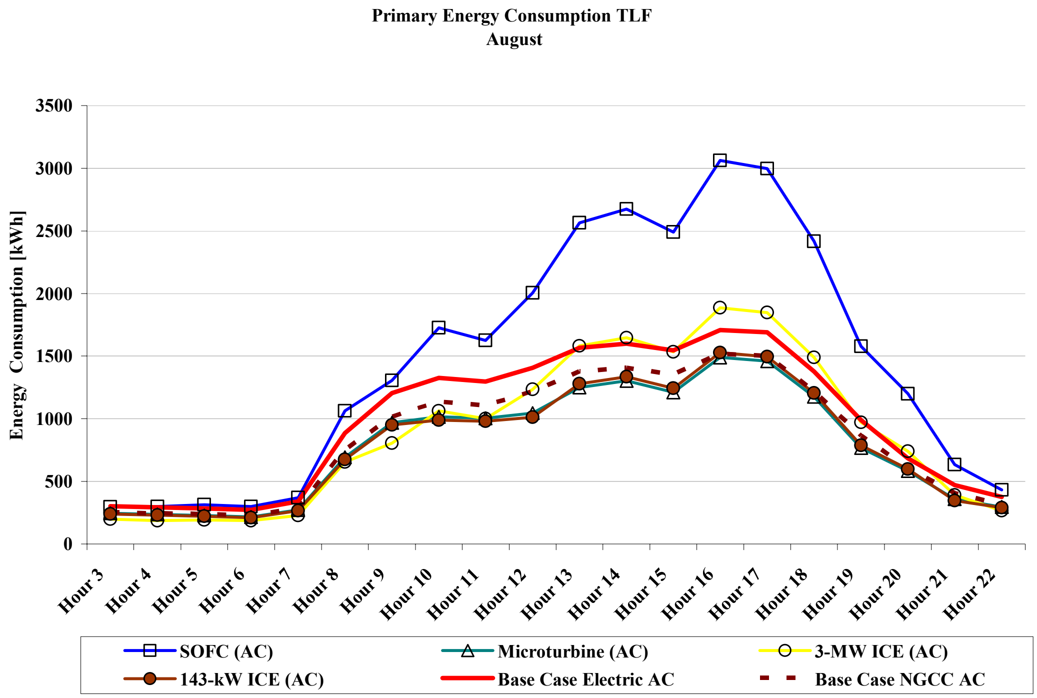

Figure 40: Primary Energy Consumption during a Typical Day in August (TLF).

4.2 Global Warming Potential (GWP) (TLF)

4.2.1 Annual GWP Analysis (TLF)

As shown in Figure 41, the annual GWP emission profile resembles the annual primary energy consumption (TLF) in section 4.1.1. Refer to explanation given in the annual primary analysis section for rationale. The main exception between the annual primary energy consumption and the GWP is that the SOFC (using AC) had lower GWP than the average electric mix, whereas, it had higher primary energy consumption than the average electric.

Generally, when comparing the GWP by all the processes, the 3-MW ICE (AC) had the lowest annual GWP followed by the NGCC (NGCC using EC for cooling had lower GWP than with AC), the 143-kW ICE (AC), the 3-MW ICE (AC), the SOFC (AC) and finally the average electric mix (EC).

The annual GWP emission distribution from the 3-MW ICE (AC) was about 89% CO_2 (95% of the CO_2 originated from the cogeneration combustion process, 2.5% from the gas turbine compressor, and the rest from upstream processes), 10% CH_4 (45% from gas extraction, 29% from gas processing, 15% from the cogeneration combustion process, 9% from gas pipelines, and rest from coal extraction and other upstream processes), and 0.9% N_2O (92% from the cogeneration combustion process, 6% from gas turbine compressor, and the rest from other upstream processes).

The annual GWP emission distribution from the 143-kW ICE (AC) differed from the 3–MW ICE because with the 143-kW ICE, some of the emissions came from the average electric mix as it required supplemental electricity to meet the electric energy use of the building. The GWP distribution from the 143-kW ICE was 91% CO_2 (56% of the CO_2 originated from the cogeneration combustion process, 31% from coal driven steam turbine, 6% from gas turbine, 2% from waste driven steam turbine, and the rest from other upstream processes), 8% CH_4 (the majority of the CH_4 emission originated from gas extraction and processing operations, 22% from coal extraction, 11% from cogeneration combustion process, and 7% from gas pipelines), and 1% NO_2 (44% originated from the cogeneration combustion process, 42% from the coal driven steam turbine, 6% from gas turbine, 3% form gas turbine compressor, and rest from other upstream processes).

The GWP emission distribution from the microturbine (AC) was 93% CO_2 (57% from the cogeneration combustion process, 30% from coal driven steam turbine, 6% from gas turbine, 2% from waste driven steam turbine, and rest from other processes), 6% CH_4 (36% from gas extraction, 27% from coal extraction, 24% from gas processing, 8% from gas pipelines, and the rest from other upstream processes), and 0.07% N_2O (75% from coal driven steam turbine, 11% from gas turbine, 4% from gas compressor, and the rest from other upstream processes).

The GWP emission distribution from the NGCC (AC) was 91% CO_2 (57% from the combined cycle combustion process, 38% from the gas boiler, 2% from the gas turbine compressor, and the rest from other upstream processes), 8% CH_4 (the majority originated from gas extraction and processing, and only about 1% from the combined cycle combustion process), and 0.5% NO_2 (77% from the combined cycle combustion process, 9% from gas boiler, 9% from gas compressor, and rest from other upstream processes).

Although the GWP emission distribution from the NGCC (EC) was similar to the NGCC (AC), the sources of emissions were different, mainly because the use of the gas boiler was limited to heating, as no additional heat was used for absorption cooling. For the NGCC (EC), 72% of the CO_2 emissions originated from the combined cycle combustion process, 22% from the gas boiler, 2% from gas turbine compressor, and rest from other upstream processes; the sources of CH_4 emissions were similar to that from the NGCC (AC); and for N_2O, 85% of the emissions originated from the combined cycle combustion process, 8% from the gas turbine, 5% from the gas boiler, and rest from other upstream processes.

The GWP emission distribution from the average electric mix (AC), as well as the average electric mix (EC), was 93% CO_2, 6% CH_4, and 1% N_2O. For the average electric mix (AC), 55% of the CO_2 emissions originated from coal extraction, 25% from the gas boiler, 10% from the gas turbine, 3% from waste driven steam turbine, and 2% from oil driven steam turbine. As the use of the gas boiler was limited to heating with average electric mix (EC), more of the CO_2 emissions shift from the gas boiler to coal and gas driven turbines: 65% of the CO_2 emissions originated from the coal driven steam turbine, 12% from the gas turbine, 13% from the gas boiler, 4% from waste driven steam turbine, and 2% from oil driven steam turbines. About

58% of the CH_4 emissions, with the average electric mix (AC), originated from coal extraction, 31% from gas extraction and processing, and 4% from gas pipelines; whereas, for the average electric mix (EC), about 72% of the CH_4 emissions originated from coal extraction, 18% from gas extraction and processing operation, and 2% from gas pipelines. For both the average electric mix (AC) and average electric mix (EC), about 76% of the N_2O emissions originated from coal driven steam turbine, 11% from gas turbine, and 3% from the gas boiler.

Generally, there was no marked reduction in GWP emissions with AC use in average electric mix or NGCC relative to the EC use; contrary to the case with primary energy consumption, where the use of EC resulted in lower primary energy consumption compared to AC.

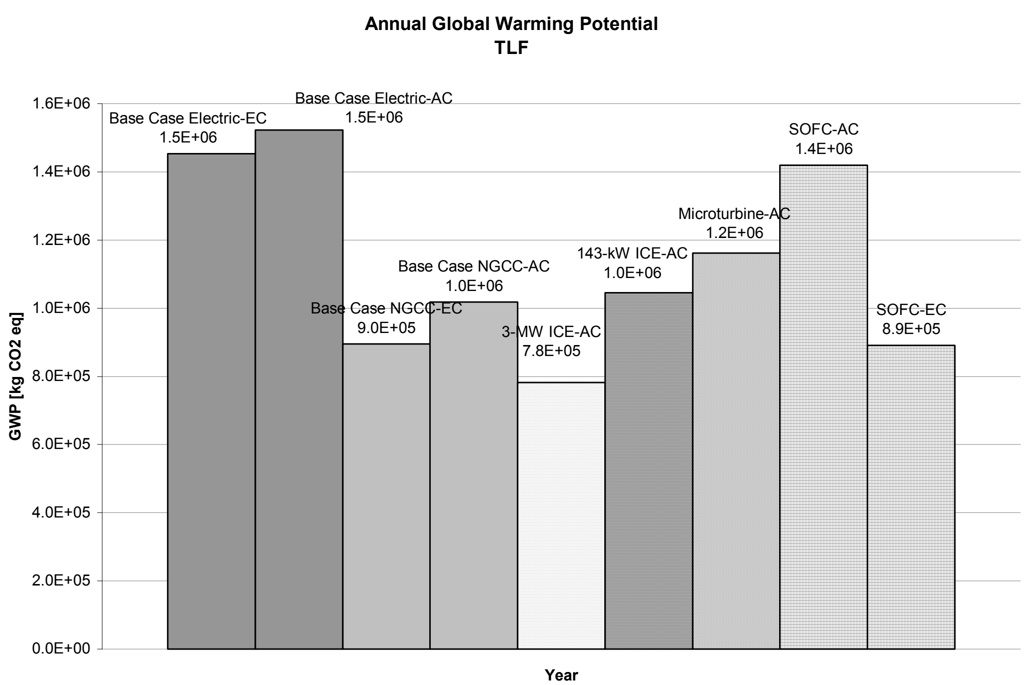

Figure 41: Annual GWP (TLF).

4.2.2 Typical Day in a Month GWP Analysis (TLF)

January

As shown in Figure 42, during a typical day in January, the GWP of all the cogeneration processes corresponded to their thermal efficiencies, where the process with the lowest thermal efficiency produced the highest emissions: the SOFC produced more emissions than the 3-MW ICE followed by the 143-kW ICE and finally the microturbine. SOFC produced approximately twice as much emission GWP emissions as the other cogeneration processes and also approximately twice as much as the average electric mix and the NGCC. All the other cogeneration processes produced comparable emissions to those from the NGCC and the average electric generation mix, where the average electric mix had the highest emissions within that category.

In a typical day in January, both the ICE cogeneration processes had approximately equal GWP emissions distribution (magnitudes are given in Figure 42): 89% CO_2, 10% CH_4, and 0.9% N_2O. In both processes, about 95% of the carbon dioxide emissions originated from the cogeneration units, 3% from the gas turbine compressor, and 0.9% from the gas boiler. Most of the methane emissions originated from upstream operations, such as gas extraction and processing, and only 15% originate from the cogeneration units. About 93% of the nitrous oxide emissions originated from the cogeneration combustion units, 6% from the gas turbine compressor, 0.8% from the coal driven steam turbine, and about 0.5% from the gas boiler.

GWP emissions distribution from the microturbine in a typical day in January was as follows: about 92% CO_2, 7% CH_4, and 0.06% N_2O. Most of the carbon dioxide emissions, about 96%, originated from the cogeneration unit, 2% from the gas compressor, and about 0.7% from the gas boiler. Nearly all of the methane emissions originated from upstream processes, such as gas extraction, processing, and transportation. About 75% of the nitrous oxide emissions originated from the gas turbine compressor, 10% from coal driven steam turbine, 7% from gas boiler, and about 2% from oil driven steam turbine.

GWP emissions distribution from the SOFC was about 95% CO_2, 5% CH_4, and 0.1% N_2O. About 90% of the carbon dioxide emissions originated from natural gas reforming to hydrogen. Most of the methane emissions resulted from upstream processes, such as gas extraction and processing. About 85% of the nitrous oxide emissions resulted from the gas turbine compressor and the remaining emissions originated from gas and coal driven steam turbines.

The GWP emissions distribution from the NGCC was about 91% CO_2, 8% CH_4, and 0.5% N_2O. About 55% of the carbon dioxide emissions originated from the gas boiler, 41% from the NGCC unit, 2% from the gas turbine compressor, and the remaining from upstream processes, such as coal driven steam turbine. Most of the methane emissions resulted from upstream processes, such as gas extraction and processing and only about 0.7% from the NGCC. About 69% of the nitrous oxide emissions resulted from the NGCC, 17% from the gas boiler, 11% from the gas compressor, and the remaining from upstream processes such as oil and coal driven steam turbines.

GWP emissions distribution from the average electric was about 93% CO_2, 6% CH_4, and 1% N_2O. About 40% of the carbon dioxide emissions originated from the gas boiler, and the remaining from upstream processes: 44% from coal driven steam turbine, 8% from gas turbine, 3% from waste driven steam turbine, 1% from oil driven steam turbine, and about 0.9% from the gas turbine compressor. About 43% of the methane emissions originated from coal extraction processes, and the remaining from gas extraction, processing, and transportation. About 73% of the nitrous oxide emissions originated from the coal driven steam turbine, 10% from gas driven gas turbine, 6% from the gas boiler, and the remaining from other electric generation upstream processes.

<u>May</u>

As shown in Figure 43, in a typical day in May, the GWP of all the cogeneration processes corresponded to their thermal efficiencies, where the process with the lowest thermal efficiency had the highest GWP. An exception was the 3-MW ICE which had less GWP than both the 143-kW ICE and the microturbine although it had lower thermal efficiency than both of them. This is because the 3-MW ICE, having higher electrical efficiency, produced slightly higher electricity than required by the building while the other two cogeneration processes required supplemental electricity to meet the electric energy use of the building.

Unlike in January, where the SOFC had approximately twice the GWP emissions as the other cogeneration processes, in May, the SOFC had comparable GWP to the other processes, but still had the highest GWP compared to the other cogeneration units.

In a typical day in May, unlike in January, the GWP emissions distribution from the ICE cogeneration processes differed because the 143-kW required some supplemental electricity to meet the electric energy use of the building while the 3-MW ICE co-generated enough electricity to meet the electric energy usage. The GWP emissions distribution from the 143-kW ICE (magnitudes are given in Figure 43) was about 91% CO_2, 8% CH_4, and 1% N_2O. About 60% of the carbon dioxide emissions originated from the cogeneration unit while the majority of the remaining originated from upstream processes: 28% from the coal driven steam turbine, and 5% from gas driven gas turbine. About 12% of the methane emissions originated from the cogeneration process and the rest originated from upstream operations, such as gas and coal extraction and processing. About 47% of the nitrous oxide emissions originated from the cogeneration combustion process, 38% from the coal driven steam turbine, and about 6% from the gas driven gas turbine, and 3% from gas turbine compressor.

The GWP emissions distribution from the 3-MW ICE was about 89% CO_2, 10% CH_4, and 0.9% N_2O. Since the 3-MW ICE utilized the co-generated electricity to meet the electric energy use of the building without the need for supplemental electricity from the grid, a higher percentage of the GWP emissions originated from the cogeneration combustion process unlike the 143-kW ICE where some of the GWP emissions originated from upstream electric generation processes. About 94% of the carbon dioxide emissions originated from cogeneration combustion process, 2% from gas turbine compressor, and 0.8% from the gas boiler. About 15% of the methane emissions originated from the cogeneration process and the rest originated from upstream operations, such as gas extraction and processing. About 91% of the nitrous oxide emissions originated from the cogeneration unit, 5% from gas turbine compressor, and the rest from upstream processes, such as the coal driven steam turbine.

GWP emissions distribution from the microturbine was as follows: about 93% CO_2, 7% CH_4, and 0.06% N_2O. Since the microturbine, similar to the 143-kW ICE, required some supplemental electricity to meet the electric energy use of the building, some of the GWP emissions originated from upstream electric generation processes from the grid. About 60% of the carbon dioxide emissions originated from the cogeneration unit, 28% from coal driven steam turbine, 5% from gas driven gas turbine, 2% from waste driven steam turbine, and about 1% from the gas compressor. Nearly all of the methane emissions originated from upstream processes, such as gas extraction, processing, and transportation. Most of the nitrous emissions originated from the electric generation from coal and gas driven steam turbine and about 5% from the gas turbine compressor.

GWP emissions distribution from the SOFC was about 95% CO_2, 5% CH_4, and 0.1% N_2O. About 90% of the carbon dioxide emissions originated from natural gas reforming to hydrogen and the rest from gas turbine compressor. Most of the methane emissions resulted from upstream processes, such as gas extraction and processing. Most of the nitrous oxide emissions resulted from the gas turbine compressor and the remaining emissions originated from gas and coal driven steam turbines.

The GWP emissions distribution from the NGCC was about 91% CO_2, 8% CH_4, and 0.5% N_2O. About 55% of the carbon dioxide emissions originated from the NGCC, 40% from the gas boiler, 2% from the gas turbine compressor, and the remaining from upstream processes, such as coal driven steam turbine. Most of the methane emissions resulted from upstream processes, such as gas extraction and processing and only about 1% from the NGCC. About 76% of the nitrous oxide emissions resulted from the NGCC, 10% from the gas boiler, 9% from the gas compressor, and the remaining from upstream processes such as oil and coal driven steam turbines.

GWP emissions distribution from the average electric mix was about 93% CO_2, 6% CH_4, and 1% N_2O. About 55% of the carbon dioxide emissions originated from coal driven steam turbine, 26% from the gas boiler, and about 10% from gas driven gas turbine, 4% from waste driven steam turbine, 2% from oil driven steam turbine, and about 0.6% from the gas turbine compressor. About 57% of the methane emissions originated from coal extraction processes, and the remaining from gas extraction, processing, and transportation. About 75% of the nitrous oxide emissions originated from the coal driven steam turbine, 11% from gas driven gas turbine, and 3% from the gas boiler while the remaining from other electric generation upstream processes.

August

As shown in Figure 44, during a typical day in August, GWP emissions from all the cogeneration processes corresponded to their thermal efficiencies where the process with the lowest efficiency had the highest emissions. However, the microturbine produced more emissions than the 143-kW ICE although the former had a higher thermal efficiency. This was because the microturbine didn't produce enough electricity while following the thermal load to meet the electric energy use of the building while the 143-kW ICE was able to utilize the co-generated electricity to meet the electric energy usage.

Unlike in May, the SOFC had much higher GWP than the average electric mix and approximately twice as much GWP as the other cogeneration units. All the other cogeneration processes had similar and comparable GWP to the NGCC because their range of thermal efficiencies was close.

In a typical day in August, as the cooling energy and electric energy use of the building increased from May, the cogeneration processes were able to utilize more of the co-generated electricity as they follow the thermal load. The GWP emissions distribution from both the ICE in August became similar, unlike in May, because the 143-kW and the 3-MW were both able to co-generate enough electricity to meet the electric energy use of the building without the need for supplemental electricity. The GWP emissions distribution from the ICE processes (magnitudes are given in Figure 44) was about 89% CO_2, 10% CH_4, and 0.9% N_2O. About 94% of the carbon dioxide emissions originated from the cogeneration combustion processes, 2% from gas turbine compressor, and 0.8% from the gas boiler. About 15% of the methane emissions originated from the cogeneration process and the rest originated from upstream operations, such as gas extraction and processing. About 91% of the nitrous oxide emissions originated from the cogeneration combustion, 5% from gas turbine compressor, and the rest from upstream processes, such as the coal driven steam turbine.

GWP emissions distribution from the microturbine was as follows: about 93% CO_2, 7% CH_4, and 0.1% N_2O. Although the microturbine co-generated a significant amount of electricity it still required some supplemental electricity to meet the electric energy use of the building; this resulted in less percentage of N_2O emissions compared to May, and also higher percentage of the emissions originated from the cogeneration combustion process. About 91% of the carbon dioxide emissions originated from the cogeneration combustion process while only 4% from coal driven steam turbine and about 1% from the gas compressor. Nearly all of the methane emissions originated from upstream processes, such as gas extraction, processing, and transportation. Unlike in May where a higher percentage of the nitrous oxide emissions originated from the electric generation processes, such as coal (74%) and gas (11%) driven steam turbine and about 5% from gas turbine compressor, in August, about 33% of the nitrous oxide emissions originated from the gas turbine compressor, and 44% from coal driven steam turbine and 7% from gas driven gas turbine.

GWP emissions distribution from the SOFC remained the same in August as in May the only difference is in the magnitude of emissions: about 95% CO_2, 5% CH_4, and 0.1% N_2O. About 90% of the carbon dioxide emissions originated from natural gas reforming to hydrogen and the rest from gas turbine compressor. Most of the methane emissions resulted from upstream processes, such as gas extraction and processing. Most of the nitrous oxide emissions resulted from the gas turbine compressor and the remaining emissions originated from gas and coal driven steam turbines.

The GWP emissions distribution from the NGCC was about 91% CO_2, 8% CH_4, and 0.5% N_2O. Although the GWP emissions distribution from the NGCC in August was similar to May, the sources of the emissions differed because with the increase in the cooling energy use of the building, the use of the gas boiler increased to run the absorption chiller and hence the source of emissions shifted from the NGCC to the boiler. About 45% of the carbon dioxide emissions originated from the NGCC, 49% from the gas boiler, 2% from the gas turbine compressor, and the remaining from upstream processes, such as coal driven steam turbine. Most of the methane emissions resulted from upstream processes, such as gas extraction and processing and only about 0.8% from the NGCC. About 69% of the nitrous oxide emissions resulted from the NGCC, 14% from the gas boiler, 10% from the gas compressor, and the remaining from upstream processes such as oil and coal driven steam turbines.

GWP emissions distribution from the average electric mix was about 93% CO_2, 6% CH_4, and 1% N_2O. Similar to the NGCC case, although the emissions distribution resembled that of May, the origin of the emissions differed because with the increase in cooling energy use from May to August, boiler use also increased. About 48% of the carbon dioxide emissions originated from coal driven steam turbine, 34% from the gas boiler, and about 9% from gas driven gas turbine, 3% from waste driven steam turbine, 1.5% from oil driven steam turbine, and about 0.8% from the gas turbine compressor. About 47% of the methane emissions originated from coal extraction processes, and the remaining from gas extraction, processing, and transportation. About 74% of the nitrous oxide emissions originated from the coal driven steam turbine, 11% from gas driven gas turbine, and 4% from the gas boiler while the remaining from other electric generation upstream processes.

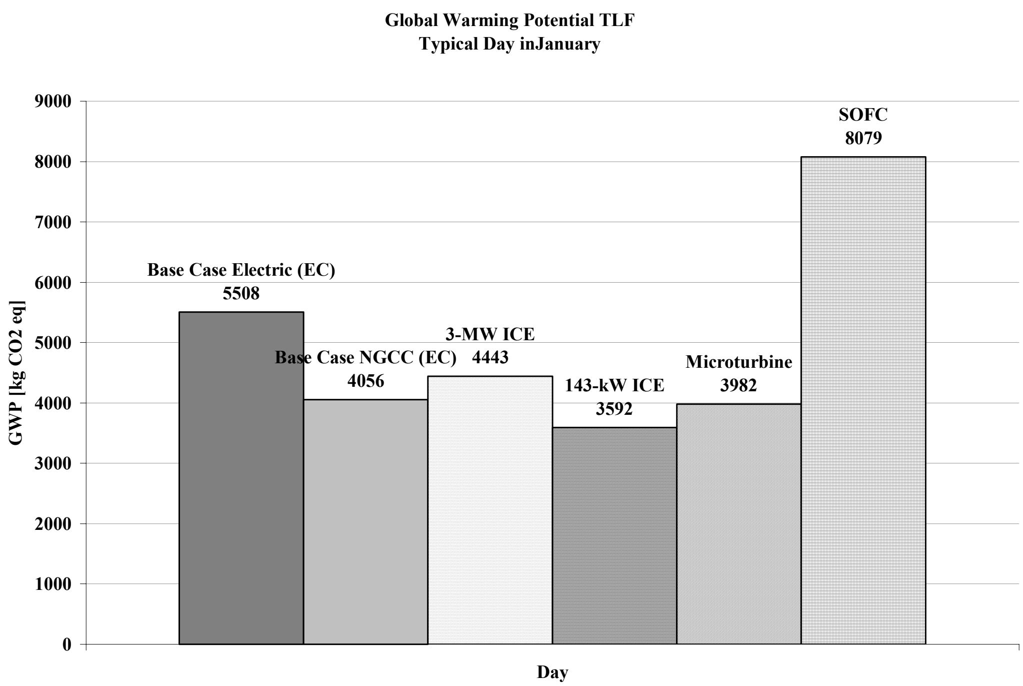

Figure 42: GWP in a Typical Day in January (TLF).

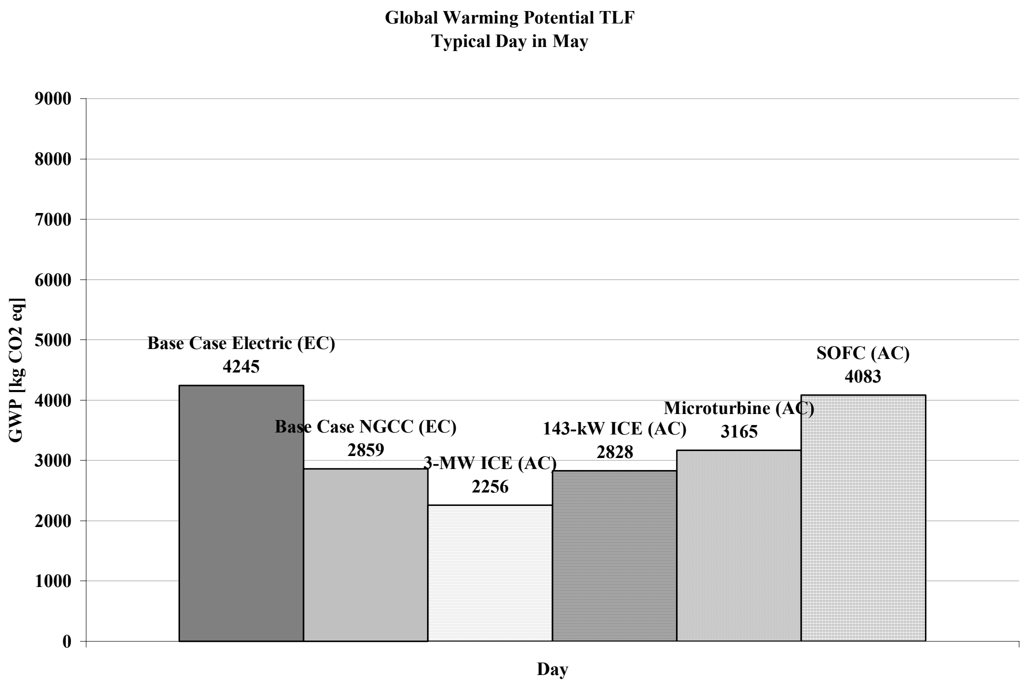

Figure 43: GWP in a Typical Day in May (TLF).

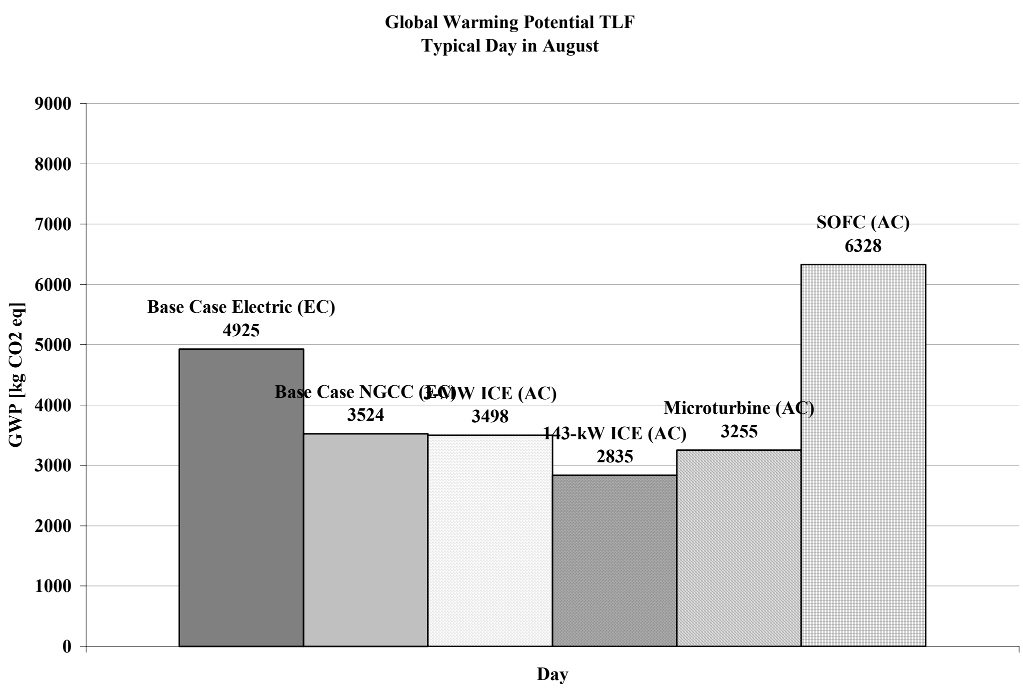

Figure 44: GWP in a Typical Day in August (TLF).

4.2.3 Hourly GWP Analysis (TLF)

January

As shown in Figure 45, during a day in January, GWP emissions from all the processes followed the thermal demand profile (refer to Figure 19), with maximum emissions at hours 8 and 19 and minimum at hour 14 except for the microturbine and the 143-kW ICE at hours 9-18, where the two units failed to satisfy the electric demand of the building and needed supplemental electricity (similar for the 3-MW ICE at hours 13-16).

GWP emissions from all the cogeneration processes corresponded to their thermal efficiencies: those with the highest thermal efficiencies produced the lowest emissions, i.e., SOFC produced more emissions than the 3-MW ICE etc. Exceptions are the microturbine, which had slightly higher thermal efficiency than the 143-kW ICE but produced more emissions; and the 3-MW ICE during the working hours of the day which had lower thermal efficiency than the ICE cogeneration processes but produced the least emissions. The 3-MW ICE had the lowest GWP emissions compared to the other processes during the working hours of the day mainly because, for most of those hours, it satisfied the electric demand without supplemental electricity. The microturbine produced more GWP emissions than the 143-kW ICE because both processes required some external electricity to meet the electric energy use of the building but because the microturbine had slightly lower electrical efficiency than the 143-kW ICE, it required more electricity to meet the electric energy usage.

At the beginning of the day (hours 3-7), all the processes produced comparable GWP emissions except for the SOFC which produced approximately twice as much. The high GWP emissions from the SOFC were due to the steam reforming of the natural gas. Although the SOFC had the highest emissions over the course of the day, its emissions dropped significantly in the middle of the day (hours 12-17), even lower than those from average electric mix.

During the early and late hours of the day, when the electric energy use of the building was low and the thermal energy use was high, all the cogeneration processes produced more electricity than required. During those hours, the source of the GWP emissions was predominately from the cogeneration units. For instance, at hours 3, 8, and 20, although the magnitude of the GWP emissions was different, the GWP emissions distribution from the 143-

kW ICE, as well as the sources of emissions, was similar: 89% of the GWP emissions were CO_2, 10% CH_4, and 0.9% N_2O. During these hours, about 95% of the carbon dioxide emissions originated from the cogeneration combustion process, 2% from the gas turbine compressor, and rest from other upstream operation. About 15% of the methane emissions were from the cogeneration combustion process while the rest of the methane emissions originated from upstream gas extraction and processing operations. During those hours, about 93% of the nitrous oxide emissions originated from the cogeneration combustion process, 6% from the compressor, and 0.7% from the coal driven steam turbine while the remaining emissions originated from other upstream processes.

On the other hand, during the working hours of the day (hours 9-17), the microturbine and the 143-kW ICE didn't produce enough electricity while following the thermal load and required supplemental electricity to meet the electric energy use of the building. During these hours, the GWP emissions distribution, as well as the sources of emissions, changed from the early hours of the day as electricity was added from the grid. For instance, at hour 12, the GWP emissions distribution from the 143-kW ICE was 91% CO_2, 8% CH_4, and 1% N_2O. At that hour, 58% of the carbon dioxide emissions originated from the cogeneration combustion process, 1.5% from the gas turbine compressor, and the rest of the carbon dioxide emissions originated from upstream electric generation processes: 29% from coal driven steam turbine, 5% from gas driven gas turbine, and 2% from waste driven steam turbine. About 12% of the methane emissions originated from cogeneration combustion process, 20% from coal extraction process, and the rest of the methane emissions were from gas extraction and processing processes. At that hour 46% of the nitrous oxide emissions originated from the cogeneration combustion process, 3% from gas turbine compressor, and the rest from upstream electric generation processes: 40% from coal driven steam turbine and 6% from gas driven gas turbine etc.

May

As shown in Figure 46, during the day in May, GWP emissions from all the cogeneration processes followed the thermal energy use profile of the building except for the microturbine and the 143-kW ICE at hours 9-17 when the two units failed to meet the electric energy use of the building and needed supplemental electricity. GWP emissions from all the cogeneration processes corresponded to their thermal efficiencies: those with the highest thermal efficiencies produced the lowest emissions. Exceptions were the 3-MW ICE in the middle of the day (8-15) which had lower thermal efficiency than the 143-kW ICE but produced the less emissions and the microturbine; which had higher thermal efficiency than the 143-kW ICE but produced more emissions. The 3-MW ICE had the lowest emissions during most of the working hours of the day mainly because it satisfied the electric energy use of the building without supplemental electricity. However, while producing co-generated electricity during hours 18-20, the 3-MW ICE produced higher emissions than the 143-kW ICE and the microturbine because it exceeded the electric energy use while at those particular hours the latter two processes met the electric energy use of the building without need for supplemental power.

At the beginning of the day (hours 3-7), all the processes produced comparable GWP emissions because they failed to meet the electric energy use and used external electricity, whereas, the NGCC appeared to produce fewer emissions than all the processes. During the working hours of the day, (hours 9-17), the SOFC and the average electric produced comparable GWP emissions to each other but higher emissions than the other cogeneration processes. During those hours, all the cogeneration processes except the SOFC produced approximately equal GWP emissions as the NGCC.

August

As shown in Figure 47, GWP emissions from all the cogeneration processes followed the thermal energy use profile of the building except for the microturbine and the 143-kW ICE at hours 9-12, where the two units required supplemental electricity to meet the electric energy use of the building. GWP emissions from all the cogeneration processes corresponded to their thermal efficiencies: those with the highest thermal efficiencies produced lowest emissions. One exception is the microturbine; which had higher thermal efficiency than the 143-kW ICE but produced more GWP emissions primarily because it required more supplemental electricity to meet the electric energy use of the building because of its relatively lower electrical efficiency.

As shown in Figure 47, at the beginning of the day, (hour 3-7), all the cogeneration processes except the SOFC produced comparable GWP emissions because they failed to meet the electric energy use of the building and used the supplemental electricity. In the middle of the day, (hours 8-17), all the cogeneration processes produced approximately the same GWP emissions as the NGCC while the SOFC produced the highest emissions, greater than the emissions from the average electric mix.

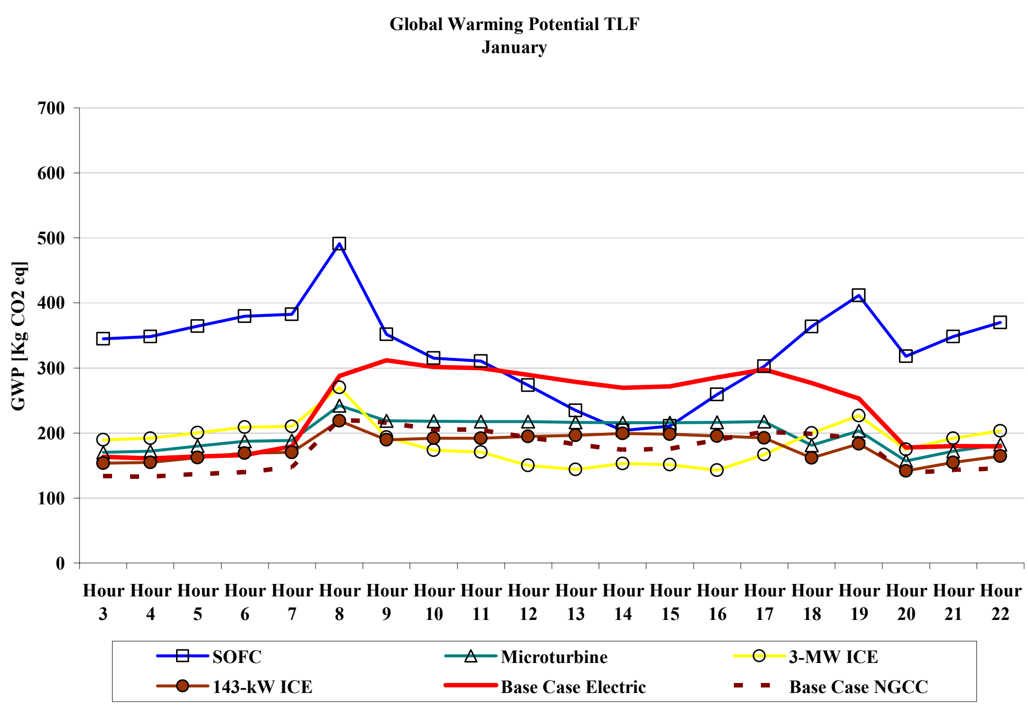

Figure 45: GWP during a Typical Day in January (TLF).

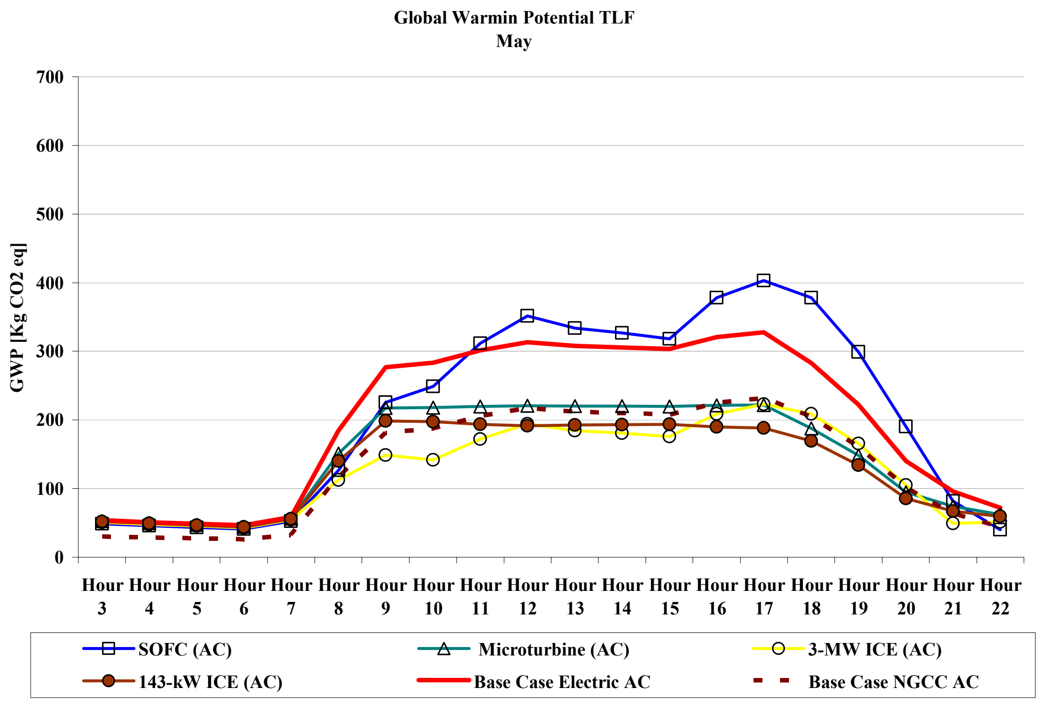

Figure 46: GWP during a Typical Day in May (TLF).

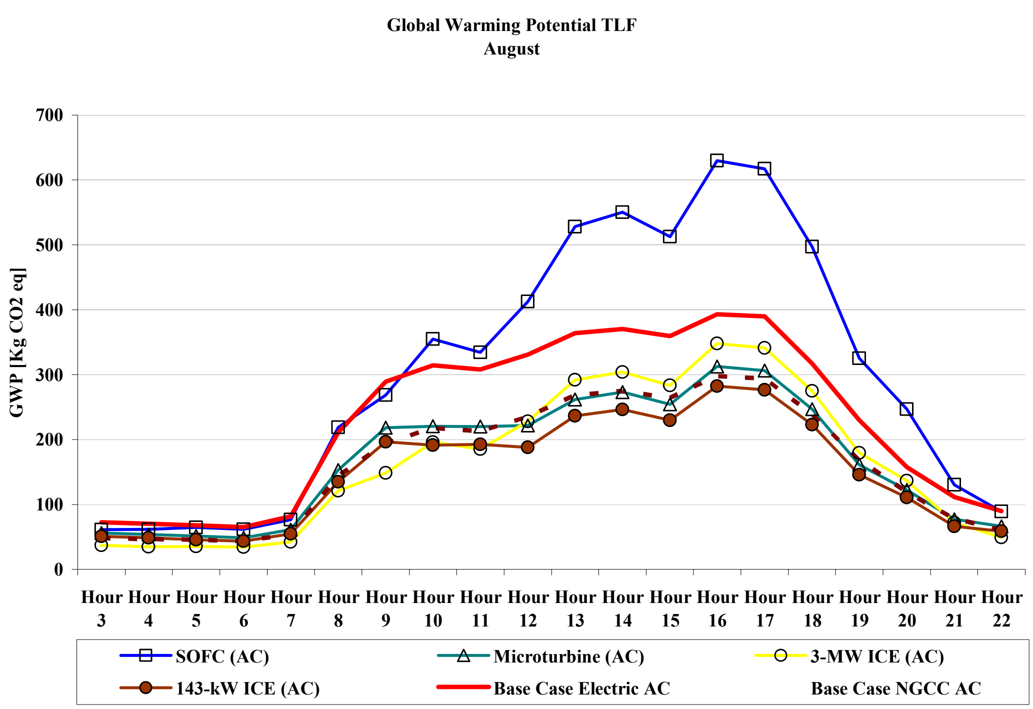

Figure 47: GWP during a Typical Day in August (TLF).

4.3 Tropospheric Ozone Precursor Potential (TOPP) (TLF)

4.3.1 Annual TOPP Analysis (TLF)

Unlike with primary energy consumption and GWP, thermal efficiency ratios were not the main factors affecting the TOPP emissions from the cogeneration processes. Rather the performance of the processes was the deciding factor. Generally, the SOFC and the microturbine had the lowest TOPP emissions followed by the ICE, which had similar performance to the NGCC, whereas, the average electric generation mix had the highest TOPP emissions. The significant difference between the TOPP emissions from the average electric mix relative to the NGCC and the cogeneration processes was because natural gas, the main fuel for NGCC and the cogeneration systems, had lower sulfur and nitrogen content than coal and other fossil fuels used in average electric generation mix.

As shown in Figure 48, following the average electric mix (EC), the 143-kW ICE (AC) had the second highest TOPP, followed by the NGCC (EC), which had similar TOPP to the NGCC (AC) and the microturbine (AC). The 3-MW ICE (AC) came next in the list, the SOFC (EC), and finally the SOFC (AC).

The difference in TOPP between the 3-MW ICE and 143-kW ICE was mainly due to thermal and electrical efficiency ratios; as the 143-kW ICE required supplemental electricity (from the average electric mix) to meet the electrical energy use of the building while the 3-MW ICE co-generated sufficient electric energy to meet the demand. The TOPP emissions distribution from the 3-MW ICE was 35% CO (98% of which was from the cogeneration combustion process, and the rest from other upstream processes), 3% CH_4, 57% NOx (79% of the NOx emissions originated from the cogeneration combustion process, 12% from the gas turbine, 3% from coal driven steam turbine, and the rest from other upstream processes), and 4% NMVOC (83% from the cogeneration combustion process, 10% from gas pipelines, 3% from gas turbine compressor, and the rest from other upstream processes). The TOPP emission distribution from 143–kW ICE was 17% CO (91% of the CO emissions originated from the cogeneration combustion process, 2% from coal driven steam turbine, 2% from gas turbine, and the rest from other upstream processes), 2% CH_4, 76% NOx (40% from coal driven steam turbine, 27% from cogeneration combustion, 20% from gas turbine, 4% from gas turbine compressor, and the rest from other upstream processes), and 6% NMVOC (30% from coal driven steam turbine, 27% from cogeneration combustion, 21% from gas turbine, 11% from waste driven steam turbine, and the rest from other upstream processes).

The main element in TOPP emission distribution that reflected the supplemental use of electricity from average electric was the source of NOx emissions. As outlined previously, with the 143-kW ICE, a higher percentage of the NOx emissions originated from the average electric mix processes, such as coal and gas driven steam turbines, and a smaller percentage of the NOx emissions was allocated to the cogeneration combustion process; whereas, with the 3-MW ICE (no supplemental electricity was required), a higher percentage of the NOx emissions originated from the cogeneration combustion process.

The TOPP emission distribution from the microturbine was 4% CO (53% from the cogeneration combustion process, 13% from coal driven steam turbine, 9% from gas turbine, and the rest from other upstream processes), 2% CH_4, 88% NOx (49% from coal driven steam turbine, 25% from gas turbine, 10% from cogeneration combustion processor, 5% from the gas turbine compressor, and the rest from other upstream processes), and 7% NMVOC (42% from coal driven steam turbine, 30% from gas turbine, and the rest from other upstream processes). As with the 143-kW ICE, the microturbine required supplemental electricity to meet the electric energy use of the building, hence, the higher percentages of the emissions originated from the average electric mix processes. The main TOPP emission from the microturbine as outlined from the emissions distribution was NOx.

Although the SOFC had the lowest thermal efficiency (26%) compared to the other cogeneration processes, it had the lowest TOPP emission because the main emission from the SOFC was carbon dioxide (majority of CO_2 was from reforming of natural gas to hydrogen gas). The TOPP emission distribution from the SOFC (AC) was 5% CO (60% from gas turbine compressor, 4% from the cogeneration combustion process, and rest from other upstream processes), 83% NOx (86% from gas turbine compressor, 3% from gas turbine, and the rest from upstream processes), 6% CH_4, and 7% NMVOC (45% from gas turbine compressor, 37% from gas pipelines, 5% from cogeneration combustion processes, and the rest from other upstream processes).

When the thermal energy from the SOFC (referred to as SOFC-EC) was used for space and water heating only, and the co-generated electricity was used to meet part of electric energy use, (which in this case included cooling, equipment, lighting, and ventilation), the TOPP of the SOFC (EC) was slightly higher than when using SOFC (AC), which was opposite to the case with primary energy use and GWP, where the SOFC (EC) had significant lower primary energy use and GWP relative to the SOFC (AC). The difference between the TOPP of the SOFC (AC) and the SOFC (EC) was mainly because the SOFC (EC) required supplemental electricity from the average electric mix. This was evident in the TOPP emission distribution from the SOFC (EC): 3% CO (35% from gas turbine compressor, 12% from coal driven steam turbine, 9% gas turbine, and the rest from upstream processes), 86% NOx (35% from coal driven steam turbine, 29% from gas turbine compressor, 18% from gas turbine, 2% from cogeneration combustion process, and the rest from other upstream processes), 7% NMVOC (26% from coal driven steam turbine, 18% from gas turbine compressor, 18% from gas turbine, 16% from gas pipelines, 10% from waste driven steam turbine, 2% from cogeneration combustion process, and the rest from other upstream processes).

The TOPP emission distribution from the NGCC (AC) and NGCC (EC) was about 3% CO, 92% NOx, 2% CH_4, and 2% NMVOC. With NGCC (AC), about 51% of the CO emissions originated from combined cycle combustion process, 30% from the gas boiler, 9% from gas turbine compressor, and the rest from other upstream processes; whereas, with the NGCC (EC), 64% of the CO emissions originated from the combined cycle combustion process, 17% from the gas boiler, 9% from the gas turbine compressor, and the rest from other upstream processes. About 88% of the NOx emissions, with the NGCC (AC), originated from the combined cycle combustion process, 7% from the gas boiler, and 7% from the gas turbine compressor; whereas, with the NGCC (EC), 87% of the NOx emissions originated from the combined cycle combustion process, 4% from the gas boiler, and 6% from the gas turbine compressor. About 55% of the NMVOC emissions, with the NGCC (AC), originated from the gas boiler, 17% from the combined cycle combustion process, 16% from gas pipelines, and the rest from other upstream processes; whereas, 40% of the NMVOC, with the NGCC (EC), originated from the gas boiler, 27% from the combined cycle combustion process, 20% from gas pipelines.

The TOPP emission distribution from average electric mix was about 2% CO, 89% NOx, 1% CH_4, and 7% NMVOC. With the average electric mix (AC), 27% of the CO emissions originated from the coal driven steam turbine, 19% from gas turbine, 19% from the gas boiler and the rest from other upstream processes; whereas, 30% of the CO emissions originated from the coal driven steam turbine, 21% from gas turbine, and 10% from gas boiler. About 56% of the NOx emissions, with the average electric mix (AC), originated from the coal driven steam turbine, 29% from gas turbine, 4% from the gas boiler, and the rest from other upstream processes. The NOx emissions, with the average electric mix (EC), had similar distribution of the sources of emissions but there were lower NOx emissions due to the gas boiler (2%). About 41% of the NMVOC emissions, with the average electric mix (AC), originated from the coal driven steam turbine, 28% from gas turbine, 15% from waste driven steam turbine, 8% from the gas boiler, and the rest from other upstream processes. The NMVOC emissions, with the average electric mix (EC), had similar sources of emissions as the average electric (AC), except that the gas boiler has only 4% contribution to the NOx emissions Generally, there was no marked reduction in TOPP emissions by using AC versus EC, with the average electric mix and NGCC.

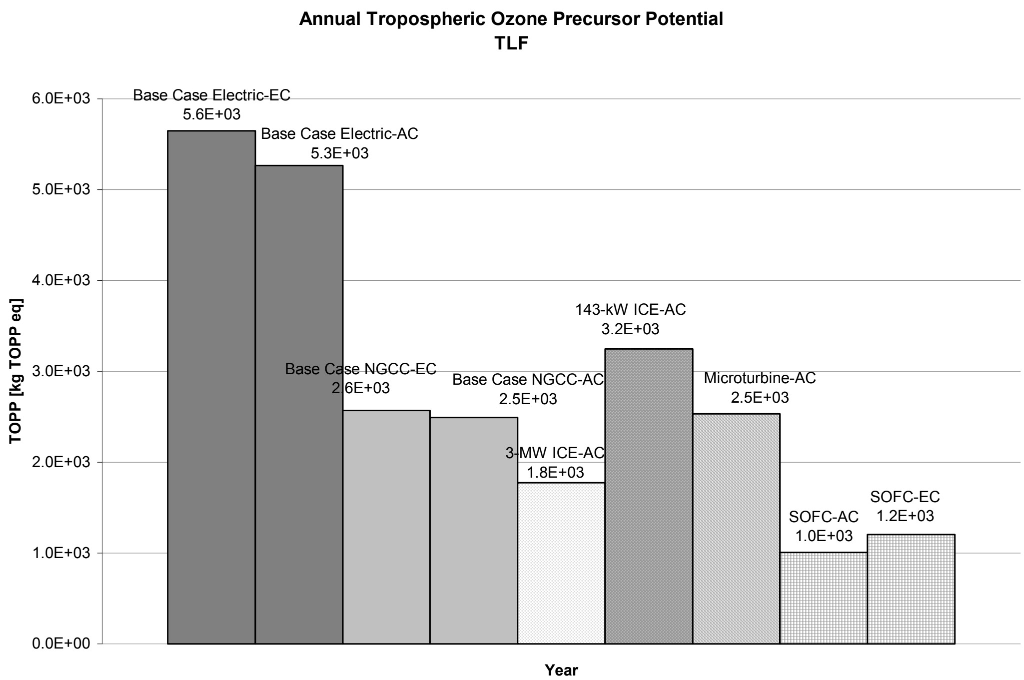

Figure 48: Annual TOPP (TLF).

4.3.2 Typical Day in a Month TOPP Analysis (TLF)

January

Generally the magnitude of the TOPP emissions was higher than that of the AP but the emission pattern was the same. As shown in Figure 49, in a typical day in January, the 3-MW ICE and the 143-kW ICE produced higher TOPP emissions compared to other cogeneration processes, followed by the NGCC, the SOFC, and the microturbine, whereas, the average electric generation mix had the highest TOPP. The major difference in TOPP emissions between the cogeneration processes was because both ICE processes had higher carbon monoxide percentages in their emissions than both the microturbine and the SOFC although their NOx emissions were relatively lower than the latter two processes. The 3-MW and the 143-kW ICE produced 36% CO, (mostly originated from the cogeneration combustion processes), while the microturbine produced about 14% CO, (mainly from cogeneration combustion process), and the SOFC produced about 5% CO, (mainly from natural gas steam reforming processes).

The SOFC produced higher TOPP emissions than the microturbine, mainly because of the higher NOx and NMVOC emissions due to its low thermal efficiency. In this case, CO effect was overshadowed by the NOx and NMVOC emissions because the latter have higher weight in ozone potential than CO (NOx is 1.2, NMVOC is 1.0 and CO is 0.11). SOFC produced 82% NOx, mostly from gas turbine compressors, and 7% NMVOC (42% of the NMVOC is from gas turbine compressor, 7% from natural gas pipelines, and 5% from the SOFC), whereas, the microturbine produced 78% NOx (60% from the microturbine unit and 26% from gas compressor while the rest from other upstream processes) and 2% NMVOC (most from gas turbine compressor and natural gas pipelines).

The NGCC had comparable TOPP emissions to that from other cogeneration processes; however, its emissions were lower than that from the 3-MWICE but approximately equal to that from the 143-kW ICE. About 89% of the TOPP emissions were NOx, (74% of which originated from the combined cycle and 13% from gas boiler), 3% is NMVOC, (most of which originated from the gas boiler), and 4% was CO, (half of which was mainly from gas boiler and the other half was from the combined cycle). Although, both the NGCC and the 143-kW ICE appeared to have similar emissions, the NGCC had higher NOx but less CO percentages in its emissions than the 143-kW ICE.

Emissions from the average electric mix were much higher than the other cogeneration processes and the NGCC because the fuels had higher percentages of TOPP pollutants than natural gas which was used by the other processes. The TOPP emissions distribution was 88% NOx, 8% NMVOC and 3% CO.

May

As shown in Figure 50, in May, the SOFC (AC) had the lowest TOPP followed by the 3-MW ICE (AC), the microturbine (AC), which had similar TOPP to the NGCC (EC), the 143-kW ICE (AC), and finally the average electric generation mix (EC).

In May, the SOFC and the 3-MW ICE were the only two cogeneration processes that co-generated more electricity than required by the building; SOFC produced almost twice as much electricity as required while the 3-MW ICE produced approximately equal amount to that required. However, as shown in Figure 50, the SOFC has the lowest TOPP emissions, as its main emissions were carbon dioxide, compared to all the other processes although it had lower thermal efficiency and no credit was taken for the high electric energy co-generated from the process. The TOPP emissions distribution of the SOFC was 83% NOx, 7% NMVOC, 5% CO, and 7% methane.

TOPP emissions from the 3-MW ICE decreased from January to May (mainly due to the decrease in CO emissions) while emissions from the microturbine and the 143-kW ICE increased because they were not able to meet the electric energy use of the building without supplemental electricity. The TOPP emission distribution from the 3-MW ICE was 58% NOx (same as in January), 5% NMVOC, and 16% CO. All the TOPP emissions from the 3-MW ICE originated mostly from the cogeneration combustion processes. The TOPP emissions distribution from the 143-kW ICE was 74% NOx, 6% NMVOC, and 18% CO (most of the TOPP emissions, 92%, was from cogeneration combustion process). Most of the 143-kW ICE emissions were from the coal and gas driven steam turbines and 30% from the cogeneration combustion process.

The microturbine produced less TOPP emissions than the 143-kW ICE although it required approximately the same amount of supplemental electricity to meet the electric energy use of the building mainly because it produced much less CO. The microturbine produced about 5% CO, (half of which originated from the cogeneration combustion process), 87% NOx (only 12% was from cogeneration combustion process), and 6% NMVOC, mostly from coal and gas driven steam turbines.

The NGCC had comparable TOPP emissions to that from other cogeneration processes; however, its emissions were lower than that from the 143-kW ICE but approximately equal to that from the 3-MW ICE. The TOPP emissions distribution from the NGCC was about 92% NOx; (80% of which originated from the combined cycle and 7% from gas boiler), 2% NMVOC; (half of which originated from the gas boiler and 16% form the NGCC), and 4% was CO; (half of which was mainly from NGCC and 30% was from the gas boiler). Although, both the NGCC and the 3-MW ICE appeared to have similar TOPP emissions distribution; the NGCC produced more NOx but less NMVOC than the 3-MW ICE.

Emissions from the average electric mix were much higher that from the other cogeneration processes and the NGCC. The TOPP emissions distribution from the average electric was about 89% NOx, 7% NMVOC and 3% CO.

August

In August, with the increase in thermal energy use of the building for cooling, all the cogeneration processes produced more electricity than required by the building except the microturbine (AC); the SOFC (AC) produced almost three times the electric energy required while the 3-MW ICE (AC) produced approximately twice as much. Nevertheless, as shown in Figure 51, the microturbine (AC) appeared to have the lowest TOPP emissions followed by the SOFC (AC), the 143-kW ICE (AC), and the 3-MW ICE (AC). Both the 3-MW ICE (AC) and the 143-kW ICE (AC) showed similar TOPP to the NGCC (EC). Generally, the TOPP emissions distribution and rationale is similar to that of January.

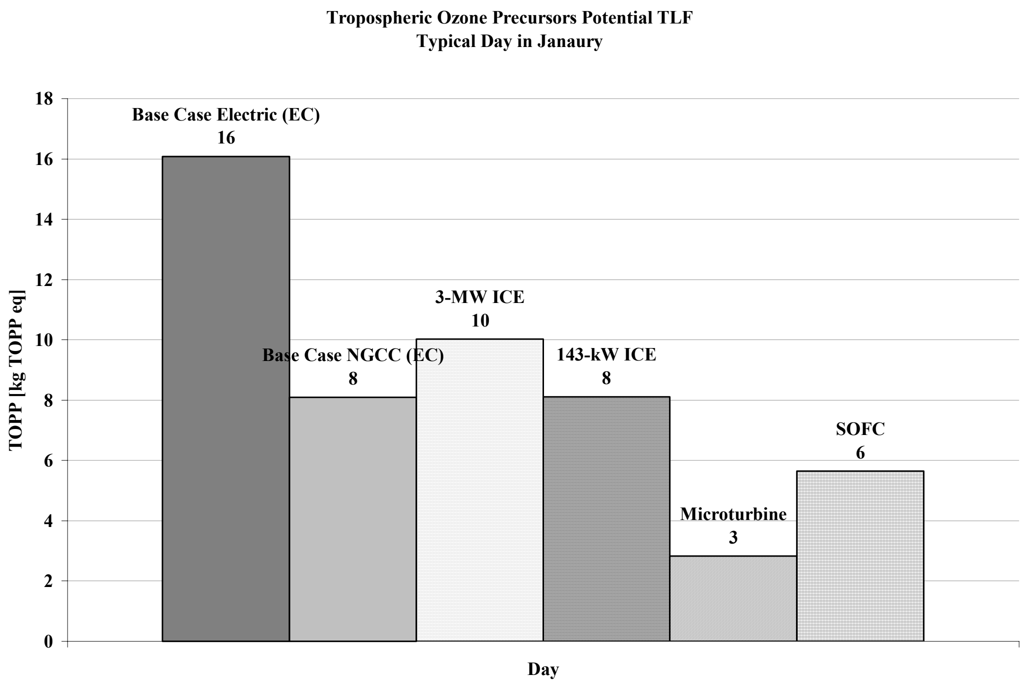

Figure 49: TOPP in a Typical Day in January (TLF).

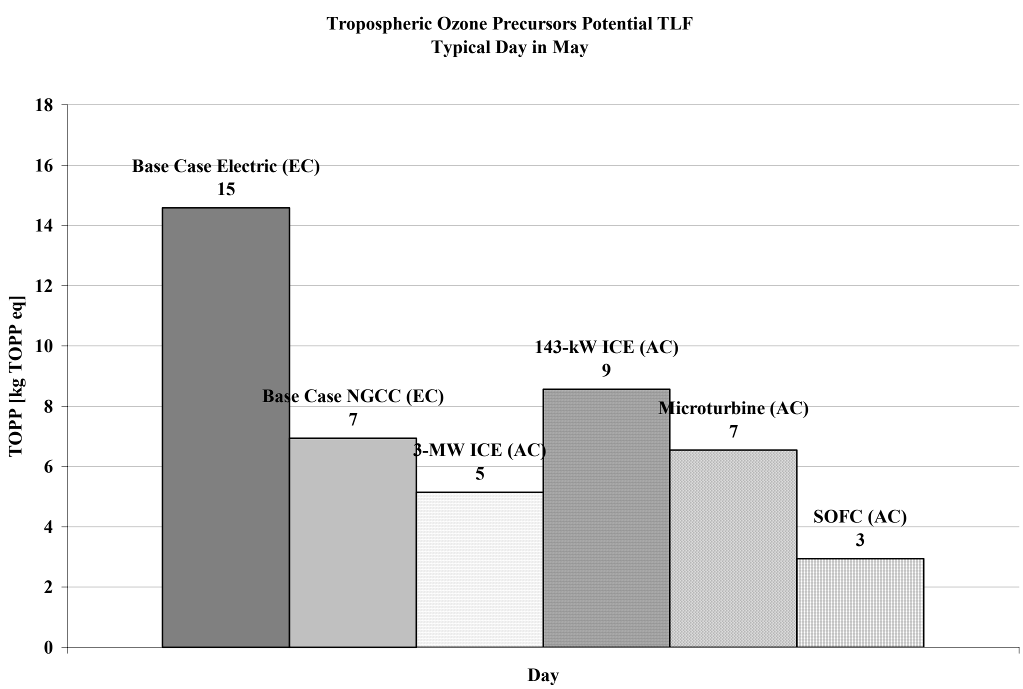

Figure 50: TOPP in a Typical Day in May (TLF).

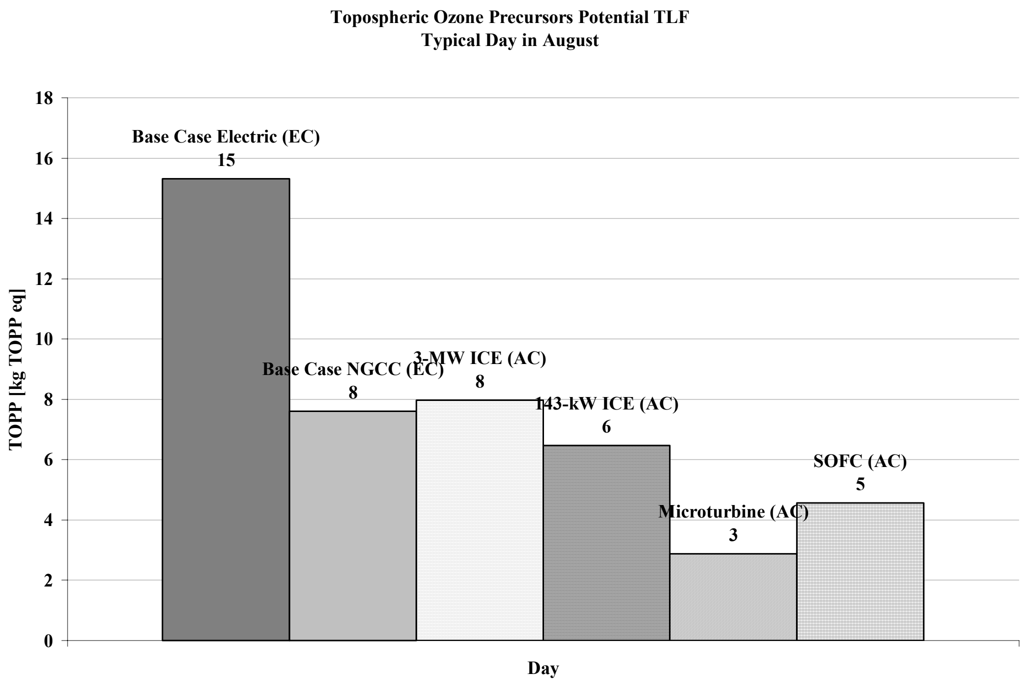

Figure 51: TOPP in a Typical Day in August (TLF).

4.3.3 Hourly TOPP Analysis (TLF)

January

TOPP emissions from all the processes followed the thermal energy use profile of the building, (refer to Figure 19), with maximum emissions at hours 8 and 19 and a minimum at hour 14 except for the microturbine and the 143-kW ICE at hours 9-17 where the two processes failed to satisfy the electric energy use and required supplemental electricity (also same with the 3-MW ICE during hours 13-16).

As shown in Figure 52, when there was no supplemental electricity required to meet the electric energy use of the building, i.e., during the beginning of the day, the microturbine produced the lowest TOPP emissions followed by the NGCC (EC), the SOFC (AC), the 143-kW ICE (AC) which was similar to the average electric, and the 3-MW ICE. However, when cogeneration processes required some supplemental electricity to meet the electric energy use of the building, the TOPP emissions increased. For example, the microturbine and the 143-kW ICE required some supplemental electricity during the working hours of the day. Because the average electric generation uses fuels such as coal which are rich in TOPP pollutants, the emissions from theses two processes were higher than the SOFC and the 3-MW ICE, (which used natural gas as the primary fuel that has less TOPP pollutants).

For instance, at hour 12 (when some supplemental electricity was required by the microturbine), the TOPP emissions distribution of the microturbine was about 88% NOx, (most of which originated from the coal and gas driven steam turbines and only 12% originated from the cogeneration combustion process), 6% NMVOC, (most of which originated from the coal and gas driven steam turbines), and 4% CO, (half of which originated from the cogeneration process). However, at hour 8 (when no supplemental electricity was required), the microturbine produced 78% NOx, (most of which originated from the cogeneration combustion process), 2% NMVOC; and 13% CO; (most of which originated from the cogeneration process).

Thus, when there was a need for supplemental electricity to meet the electric energy use of the building, more NOx and NMVOC but less CO were produced than when the cogeneration processes fully utilize their co-generated electricity, as they follow the thermal load of the building. During the hours when the cogeneration processes required supplemental electricity to meet the electric energy use of the building, the TOPP emissions originated mainly upstream from electric generation power plants, whereas, when the cogeneration processes co-generated enough electricity to meet the electric energy use, the emissions originated from the cogeneration processes. Generally, the majority of the CO emissions originated primarily from the cogeneration processes at all times.

May

The profile of hourly TOPP emissions, as well as the emissions distribution, resembled that of the AP emissions in May, as shown in Figure 53.

August

The TOPP emissions profile followed the thermal energy use profile except at hours when there was a need for supplemental electricity to meet the electric energy use of the building. For instance, as shown in Figure 54, the TOPP emissions profile of the microturbine and the 143-kW ICE followed the thermal energy use profile except during hours 7-12 when the cogeneration processes failed to meet the electric energy use of the building and required supplemental electricity. At these hours, the TOPP peaked because of the use of external electricity.

Although the SOFC had low thermal efficiency ratio and co-generated high electricity while following the thermal load of the building, its TOPP emissions were relatively low because the main emissions from the SOFC were carbon dioxide. During the hours when all the cogeneration processes did not require supplemental electricity (hours 13-20), the microturbine had the lowest TOPP emissions followed by the SOFC, which had similar emissions to the 143-kW ICE), the 3-MW ICE, the NGCC, and finally the average electric mix.

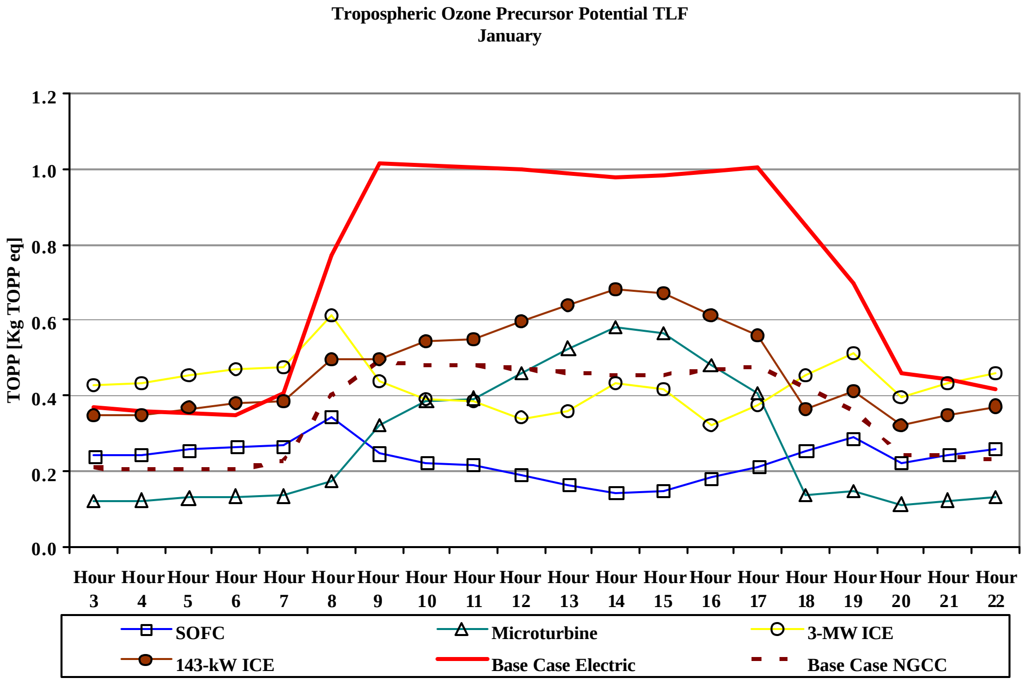

Figure 52: TOPP during a Typical Day in January (TLF).

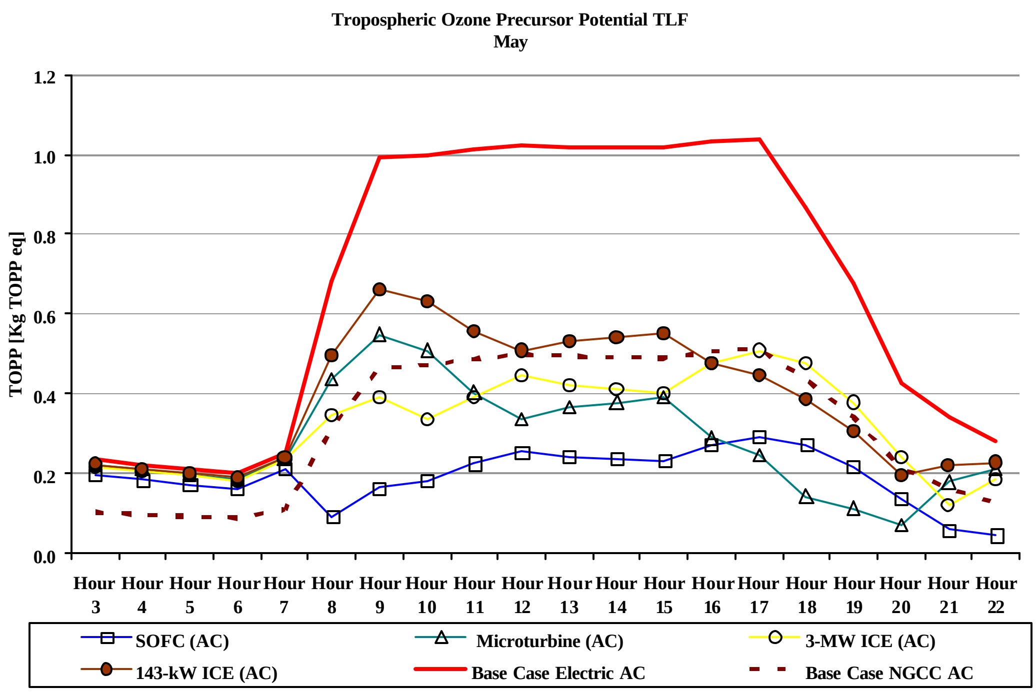

Figure 53: TOPP during a Typical Day in May (TLF).

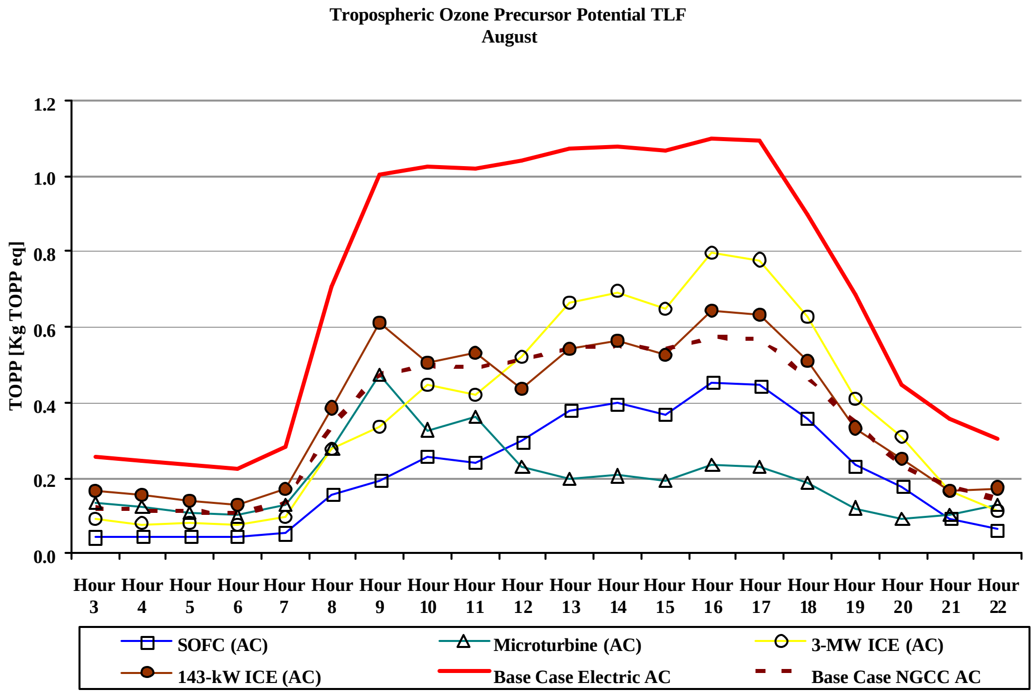

Figure 54: TOPP during a Typical Day in August (TLF).

4.4 Acidification Potential (AP) (TLF)

4.4.1 Annual AP Analysis (TLF)

The annual AP emission profile, shown in Figure 55, is similar to the annual TOPP profile (TLF). Similar to the TOPP case, because natural gas has lower sulfur and nitrogen content than coal and other fossil fuels, it has lower acidification potential, and that explains the significant difference between the AP of the average electric mix relative to the NGCC and the cogeneration processes. Following the average electric mix (EC as well as AC), the 143-kW ICE (AC) had the second highest AP; which had similar AP to the microturbine (AC), followed by the NGCC (EC), which had similar AP to the NGCC (AC). The SOFC (EC) came next in the list, followed by the 3-MW ICE (AC), and finally the SOFC (AC). Unlike with TOPP, the 3-MW ICE had relatively slightly lower AP than the SOFC (EC).

The AP emission distribution from the 3-MW ICE was 89% NOx[13] and 11% SO_2; 5% of the SO_2 emission was from the cogeneration combustion process, 57% from coal driven steam turbine, 18% from oil driven steam turbine, and the rest from other upstream processes. The AP emission distribution from 143–kW ICE was 74% NOx and 24% SO_2 (70% of the SO_2 emissions originated from coal driven steam turbine, and the rest from other upstream processes). The difference in magnitude of AP emission between the 3-MW ICE and the 143-kW ICE indicated the contribution of average electric mix to AP emissions, which was used with 143-kW ICE to provide supplemental electricity. The main AP emissions from both ICE combustion processes were NOx.

The AP emission distribution from the microturbine was 70% NOx and 28% SO_2 (72% from coal driven steam turbine, 8% from waste driven turbine, about 1% from the cogeneration combustion process, and the rest from other upstream processes).

Although the SOFC had the lowest thermal efficiency (26%) compared to the other cogeneration processes, it had relatively low AP emission because the main emissions from the

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[13] The origins of NOx emissions are the same for TOPP and AP (the difference is in their percentage contribution to overall TOPP and AP). Refer to the section of annual TOPP analysis for origins of NOx emissions.

SOFC were carbon dioxide (majority of CO_2 were from reforming of natural gas to hydrogen gas). The AP emission distribution from the SOFC (AC) was 91% NOx and 9% SO_2 (mainly from upstream coal and oil related processes). The AP emission distribution of the SOFC (EC) was 75% NOx and 22% SO_2 (70% from coal driven steam turbine, 8% from waste driven steam turbine, and the rest from other upstream processes). As with the case in TOPP, the AP of the SOFC (EC) was higher than when using SOFC (AC) because the SOFC (EC) required supplemental electricity from the average electric mix and this was evident in the AP emission distribution of the SOFC (EC), where most of the SO_2 and a large portion of NOx emissions originated from average electric mix processes.

The AP emission distribution from the NGCC (AC) and NGCC (EC) were about 93% NOx and 7% SO_2. Most of the SO_2 emissions originated from coal and oil related process but part of the emissions were from the combined cycled combustion process; 15% and 19%, for NGCC (AC) and NGCC (EC), respectively.

The AP emission distribution from average electric mix was about 69% NOx and 29% SO_2. The sources of SO_2 emissions with average electric mix (AC) and average electric (EC) were similar as the contribution of the gas boiler to the emissions was negligible. About 78% of the SO_2 emissions originated from the coal driven steam turbine, 9% from oil driven steam turbine, and the rest from other upstream processes. Generally, there was no marked reduction in AP emissions by using AC versus EC, with average electric mix and NGCC, as the contribution of the gas boiler to the emissions is negligible.

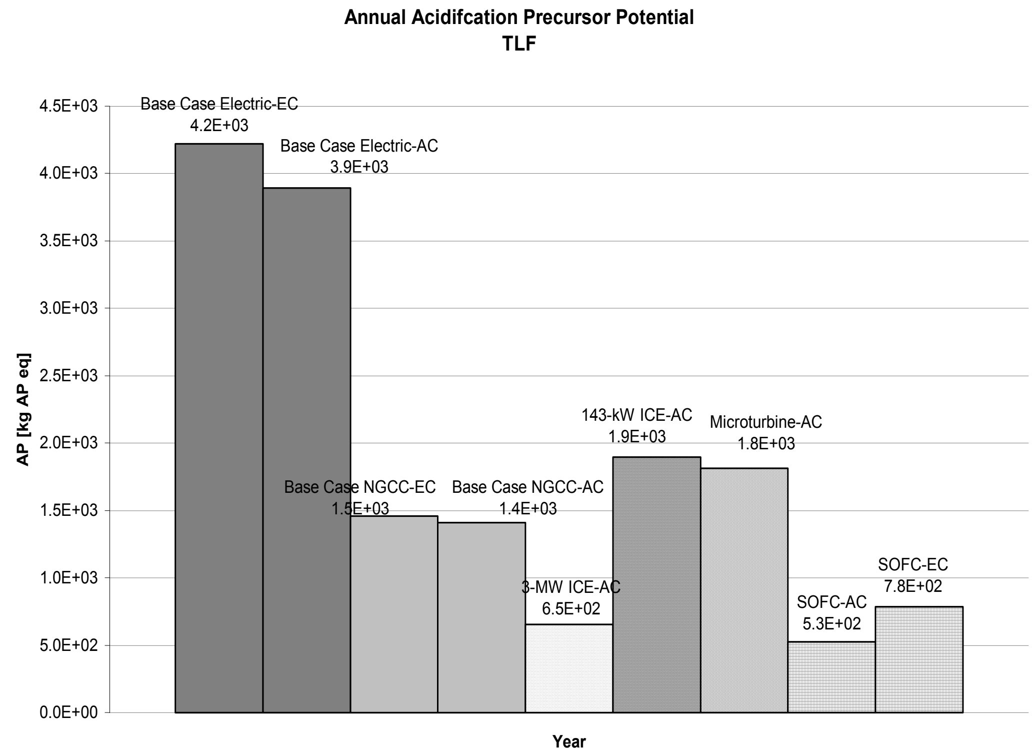

Figure 55: Annual AP (TLF).

4.4.2 Typical Day in a Month AP Analysis (TLF)

January

As shown in Figure 56, the average electric generation mix (EC) had the highest AP emissions, followed by the NGCC (EC), the 3-MW ICE (AC), the 143-kW ICE (AC), the SOFC (AC), and the microturbine (AC).

The SOFC produced approximately four times the amount of electricity as the electric energy use of the building; nevertheless, its AP emissions compared to other cogeneration processes was lower. For instance, SOFC AP emissions were approximately similar to the 143-kW ICE although the 143-kW ICE produced quarter the electricity produced from the SOFC. This might be because 92% of the AP emissions from SOFC were NOx, which mostly originated from gas turbine compressors where no NOx control used in the natural gas distribution pipelines. AP emissions from the other cogeneration processes were mainly due to NOx production from cogeneration combustion processes. For instance, the AP emissions distribution from the 143-kW ICE was about 90% NOx and 10% SO_2. About 80% of the NOx emissions originated from the cogeneration combustion process while most of the SO_2 emissions originated from coal and oil steam turbine power plants and only 5% from cogeneration process.

The NGCC had comparable AP emissions to that from the other cogeneration processes although slightly higher. Most of the AP emissions were NOx (92%); 70% of the NOx emissions originated from the NGCC and 13% from the gas boiler.

AP emissions from the average electric mix were approximately four times as much as that from the other cogeneration units and NGCC. AP emissions were 70% NOx and 30% SO_2. About 50% of the NOx emissions originated from coal driven steam turbine and 30% from gas driven gas turbine while only 7% from the gas boiler. The SO_2 emissions are mostly from the coal driven steam turbine.

May

As shown in Figure 57, in May, the SOFC and the 3-MW ICE were the only two cogeneration processes that produced more electricity than required; the SOFC produced almost twice as much electricity as the use of the building and the 3-MW ICE produced approximately equal amount of electricity to the electric energy use of the building. However, the AP emissions from both processes were approximately equal which indicates that SOFC had comparatively lower emissions.

The microturbine and the 143-kW ICE had approximately equal AP emissions but twice as much as that from the SOFC and the 3-MW ICE mainly because they required supplemental electricity to meet the electric energy use of the building. Approximately 70% of the AP emissions from the microturbine and the 143-kW were NOx and 26% were SO_2 while about 90% of the AP emissions from the SOFC and the 3-MW ICE emissions were NOx and about 10% was SO_2. Most of the NOx emissions from the microturbine were due to steam and gas turbine and only 12% of the NOx emissions originated from the cogeneration combustion process. On the other hand, 30% of NOx emissions from the 143-kW ICE originated from the cogeneration combustion process.

Because the 3-MW ICE had higher electrical efficiency than both the 143-kW ICE and the microturbine, and hence did not require supplemental electricity to meet the electrical energy use of the building, most of the NOx emissions (about 80%) were from the cogeneration combustion process. Most of the AP emissions from the SOFC originated from gas processing operations and about 87% of the NOx emissions were from the gas turbine compressor.

The microturbine and the 143-kW ICE had a higher percentage of SO_2 than the 3-MW ICE and the SOFC because they required supplemental electricity to meet the electric energy use of the building as most of the SO_2 emissions originated from coal driven steam power plants.

Similar to January, the NGCC had comparable AP emissions to that from the other cogeneration processes even slightly lower than the microturbine and the 143-kW ICE. About 90% of the AP emissions from the NGCC were NOx; 80% of the NOx emissions originated from the NGCC and 7% from the gas boiler.

Also similar to January, AP emissions from average electric were approximately three times as much as that from the other cogeneration processes and the NGCC. AP emissions were about 70% NOx and 30% SO_2; about 50% of the NOx emissions originated from coal driven steam turbine and 30% from gas driven gas turbine while only 5% from the gas boiler (use of gas boiler was much less than in January because the heat energy use of the building was lower). SO_2 emissions were mostly from the coal driven steam turbine.

August

As shown in Figure 58, the average electric generation mix (EC) had the highest AP emissions followed by the NGCC (EC), the 3-MW ICE (AC), and the 143-kW ICE (AC), which had similar emissions to both the SOFC and the microturbine.

As the cooling energy use of the building increased from May to August while the electric and heating energy use approximately remained constant, the AP emissions from the 143-kW ICE and the microturbine decreased compared to May as the 143-kW ICE was able to meet the electric energy use without need for supplemental electricity while the microturbine required some supplemental electricity to meet the demand. On the other hand, the 3-MW ICE, which produced lower AP emissions than both the microturbine and the 143-kW ICE in May, produced higher AP emissions in August because of its relatively lower thermal efficiency ratio and produced double the amount of electricity as that required. Also, the SOFC produced almost quadruple the amount of electricity as required but still remained low in emissions compared to that from the 3-MW ICE.

The microturbine and the 143-kW ICE had approximately equal AP emissions but different AP emission distributions. Approximately 77% of the microturbine AP emissions were NOx and 22% were SO_2. Unlike in May where most of the NOx emissions from the microturbine originated from the steam and gas turbine, in August most of the NOx emissions (about 44%) were from the cogeneration combustion process. On the other hand, 88% of the AP emissions from the 143-kW ICE emissions were NOx and 11% was SO_2-about 70% of NOx emissions originated from the cogeneration combustion process. AP emissions distribution from the 3-MW ICE was similar to that from the 143-kW ICE. Most of the AP emissions from the SOFC were NOx (90%)-about 87% of NOx emissions originated from the gas turbine compressor.

Similar to January and May, NGCC had comparable AP emissions to that from other cogeneration but slightly higher. About 92% of the AP emissions were NOx-75% of the NOx emissions originated from the NGCC and 10% from the gas boiler.

Also similar to January and May, AP emissions from the average electric mix were much higher than the cogeneration processes and NGCC. AP emissions were about 70% NOx and 30% SO_2-about 50% of NOx emissions originated from the coal driven steam turbine and 30%

from gas driven gas turbine while only 5% from the gas boiler (use of gas boiler was less than January because the heat energy use of the building was lower). SO_2 emissions originated mostly from the coal driven steam turbine.

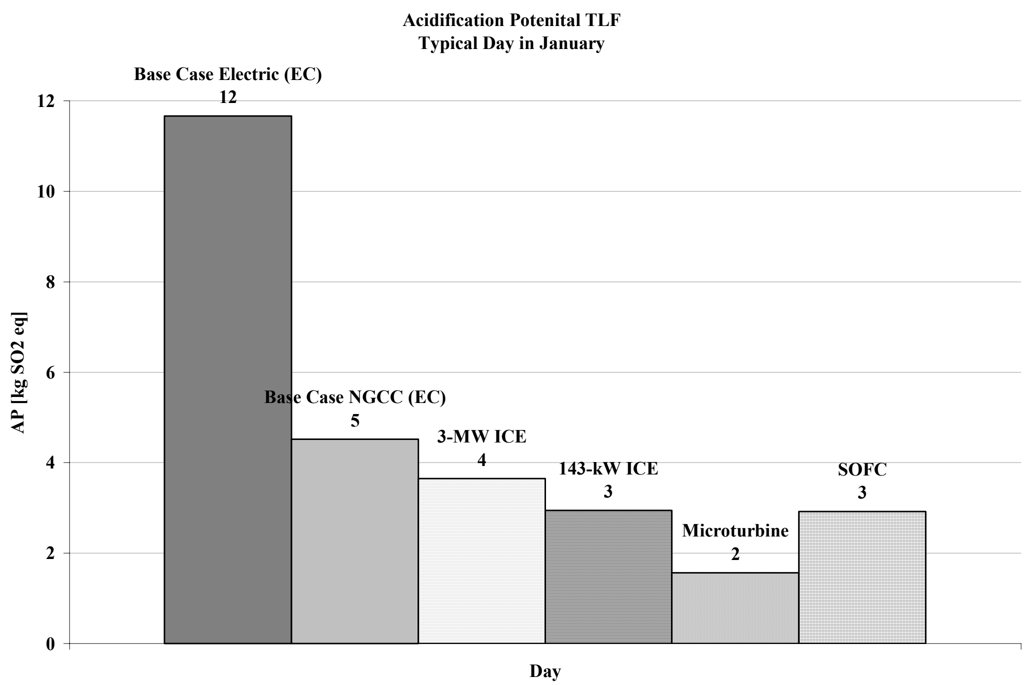

Figure 56: AP in a Typical Day in January (TLF).

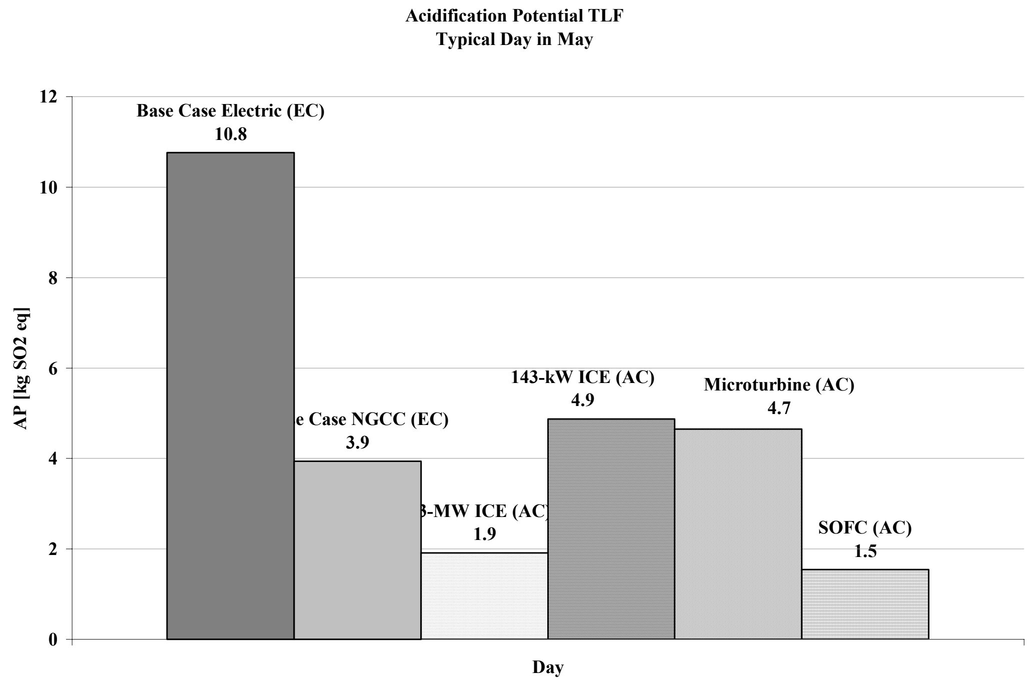

Figure 57: AP in a Typical Day in May (TLF).

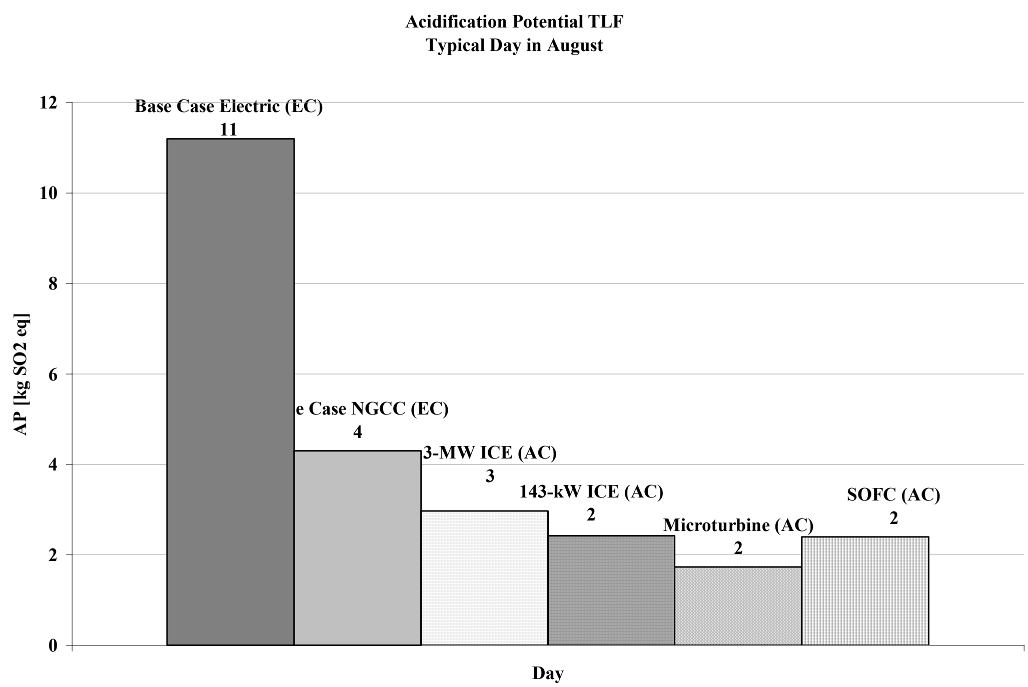

Figure 58: AP in a Typical Day in August (TLF).

4.4.3 Hourly AP Analysis (TLF)

January

As shown in Figure 59, AP emissions from all the cogeneration processes followed the thermal energy use profile of the building (refer to Figure 19), with maximum emissions at hours 8 and 19 and a minimum at hour 14 except for the microturbine and the 143-kW ICE at hours 9-17 where the two processes failed to satisfy the electric energy use of the building and required some supplemental electricity (also same with 3-MW ICE during hours 13-16).

At the beginning of the day (hour 3-7) as well as end of the day (18-22), AP emissions from all the cogeneration processes corresponded to their thermal efficiencies: those with highest thermal efficiencies produced lowest emissions except for the SOFC (having a thermal efficiency of 26%), which produced approximately equal emissions to that from the 143-kW ICE (having a thermal efficiency of 51%). During these hours the average electric generation mix produced more AP emissions than the 3-MW ICE followed by the SOFC, which had similar AP emissions to the 143-kW ICE followed by the NGCC and the microturbine.

SOFC had the lowest AP emissions during the working hours (9-17) followed by the 3-MW ICE, the NGCC, the microturbine and the 143-kW ICE, whereas, the average electric had the highest AP emissions.

During the morning hours when the cogeneration processes utilized their co-generated electricity in meeting the electric energy use of the building, most of the AP emissions originated from the cogeneration combustion processes. For example, at hour 6, the microturbine produced 80% NOx and 19% SO_2. About 60% of the NOx emissions were from the cogeneration combustion process and 27% from the gas turbine compressor. SO_2 emissions were mainly from coal and oil driven steam turbines and about 9% of the emissions were from the cogeneration combustion process.

On the other hand, during the hours when the cogeneration processes required external power to meet the electric energy use of the building, the AP emissions increased dramatically as seen with the 143-kW ICE and the microturbine at hours 9-17. For instance, at hour 12, the AP emissions distribution from the microturbine was about 70% NOx and 28% SO_2. Approximately 48% of the NOx emissions originated from coal driven steam turbine, 25% from gas driven gas turbine and 12% from the cogeneration combustion process. As the electric energy use of the building increased, more of the NOx emissions originated from upstream electric generation processes and a lower percentage of the emissions originated from the cogeneration combustion process. As for SO_2, most of the emissions were from the coal driven steam turbine and emissions from the cogeneration combustion process were negligible.

May

At the beginning of the day (hour 3-7), all the cogeneration processes required supplemental electricity to meet the electrical energy use of the building because there was no cooling load and the electricity co-generated from the processes while following the thermal load was low. As shown in Figure 60, on these hours, the average electric had the highest AP emissions followed by the 3-MW ICE, which was approximately similar to the 143-kW ICE and the microturbine, followed by the SOFC and the NGCC. Most of the AP emissions (about 70%) were NOx and about 30% were SO_2. Primarily, most of the NOx emissions (60%) originated from the coal driven steam turbine and the gas driven gas turbine while the majority of the SO_2 emissions were from the coal driven steam turbine.

During peaking hours (hours 8-10), all the cogeneration processes required supplemental electricity to meet the electric energy use of the building except the SOFC, which had the lowest AP emissions. All the AP emissions from the SOFC originated from natural gas supply and steam reforming process. During these hours, the 3-MW ICE produced fewer emissions than the 143-KW ICE and the microturbine because less supplemental electricity was required to meet the electric energy use of the building with the 3-MWl ICE than the latter two units.

At hour 8, the 3-MW and the 143-kW ICE had approximately similar AP emission distribution: 72% NOx and 25% SO_2. However, a large proportion of the NOx emissions (about 28%) from the 3-MW ICE originated from the cogeneration combustion process compared to 14% of NOx emissions from the 143-kW ICE.

There was a decrease in emissions from the SOFC during hour 8 because at that hour the cooling load had begun and no supplemental electricity was required. At this hour, about 90% of the AP emissions from the SOFC were NOx and 10% was SO_2, 85% of the NOx emissions were from the gas turbine compressor and most of the SO_2 emissions were due to coal and oil driven steam turbines.

During working hours (hours 9-17), the microturbine and the 143-kW ICE failed to meet the electric energy use of the building and required supplemental electricity. AP emissions during those hours increased with the corresponding increase in cooling load. This was indicated by the high percentage of the NOx emissions originating from the cogeneration combustion processes (approximately 50% of NOx emissions at hour 12 were from cogeneration combustion process). However, when the supplemental electricity was required to meet the electric energy use, more of the emissions originated from the average electric generation processes rather than from the cogeneration combustion processes. For instance, the peaking AP emissions at hours 8-10 were due to the corresponding high supplemental electricity that was required. At hour 8, for example, the 143-kW ICE produced 71% NOx; only 14% of the NOx were from the cogeneration combustion process while 49% was from coal driven steam turbine and 25% from gas driven gas turbine. However, at hour 12, the 143-kW ICE produced 79% NOx, 47% of the NOx emissions originated from the cogeneration combustion process and the rest was from coal driven steam turbine and gas driven gas turbine. In addition, during those peaking hours (hours 8-10), a higher percentage of SO_2 was produced; about 27% at hour 8 as compared to 19% at hour 12. Most of the SO_2 emissions originated from upstream electric generation processes.

August

As explained earlier, when supplemental electricity was required to meet the electric energy use of the building, AP emissions originated from the average electric generation processes rather than from cogeneration combustion processes. For example, as shown in Figure 61, at hour 9, the microturbine required supplemental electricity, and hence, its AP emissions were highest during that hour: 49% of the NOx emissions were from coal driven steam turbine and 25% were from the gas driven gas turbine while only 10% were from the cogeneration combustion process. However, at hour 16 when the microturbine did not require supplemental electricity to meet the electric load, 55% of the NOx emissions originated from the cogeneration process.

Generally, because the cogeneration processes use natural gas, which is low in AP pollutants, the AP emissions from the cogeneration processes were much lower when they utilized their co-generated electricity to meet the electric demand without the need for supplemental electricity, whereas, the AP emissions from the cogeneration processes increased when they required supplemental electricity to meet the electric demand of the building.

SOFC was able to exceed the electric energy use of the building at all hours of the day. The AP emissions from the SOFC increased with the decrease in the thermal energy use of the building. Although the AP emissions from the SOFC were the lowest at the beginning of the day, they increased during peaking hours and exceeded those from the microturbine.

During the hours when no supplemental electricity was required to meet the electric energy use (hours 13-20), all the cogeneration processes followed the thermal demand profile of the building (refer to Figure 19). As shown in Figure 61, the 3-MW ICE produced more AP emissions than the 143-kW ICE while the microturbine produced the lowest emissions. The SOFC produced similar AP emissions to the 143-kW ICE during these hours.

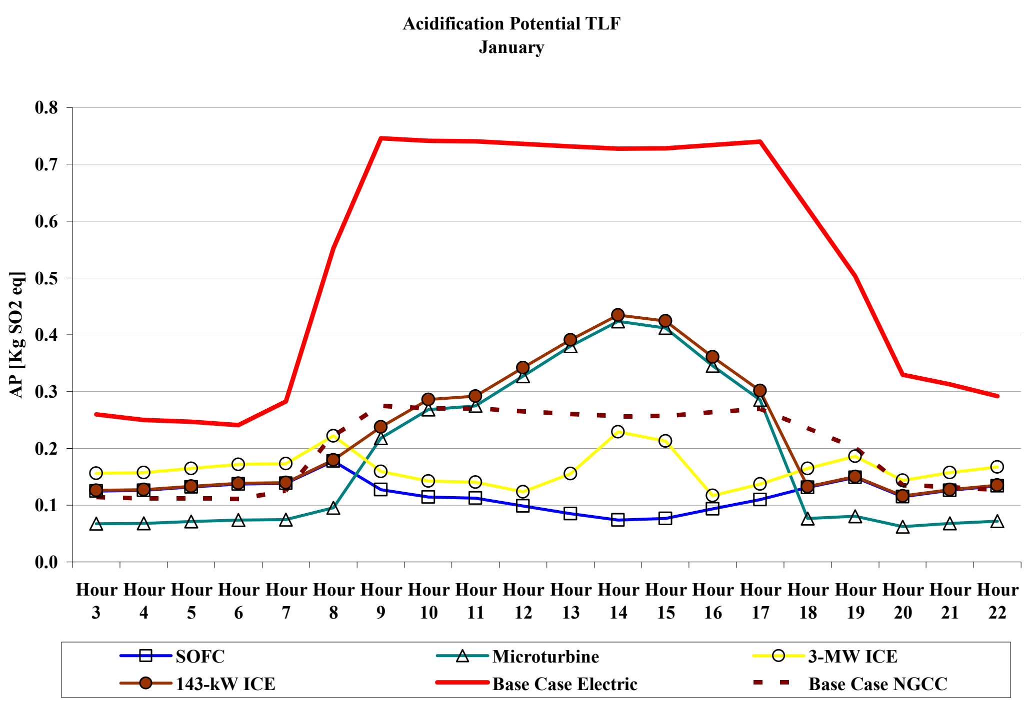

Figure 59: AP during a Typical Day in January (TLF).

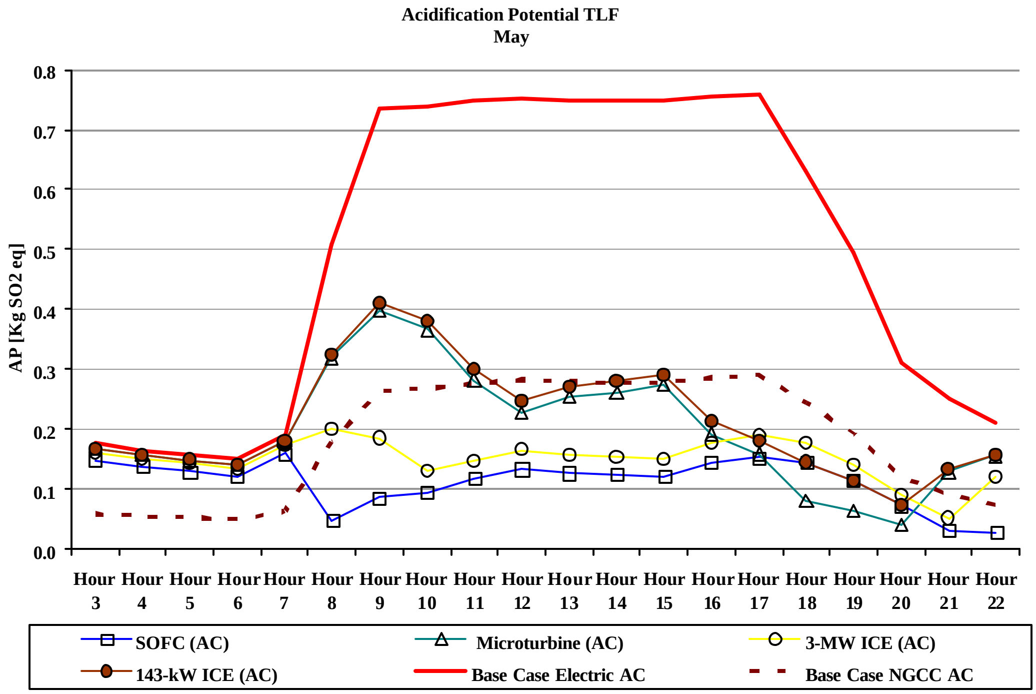

Figure 60: AP during a Typical Day in May (TLF).

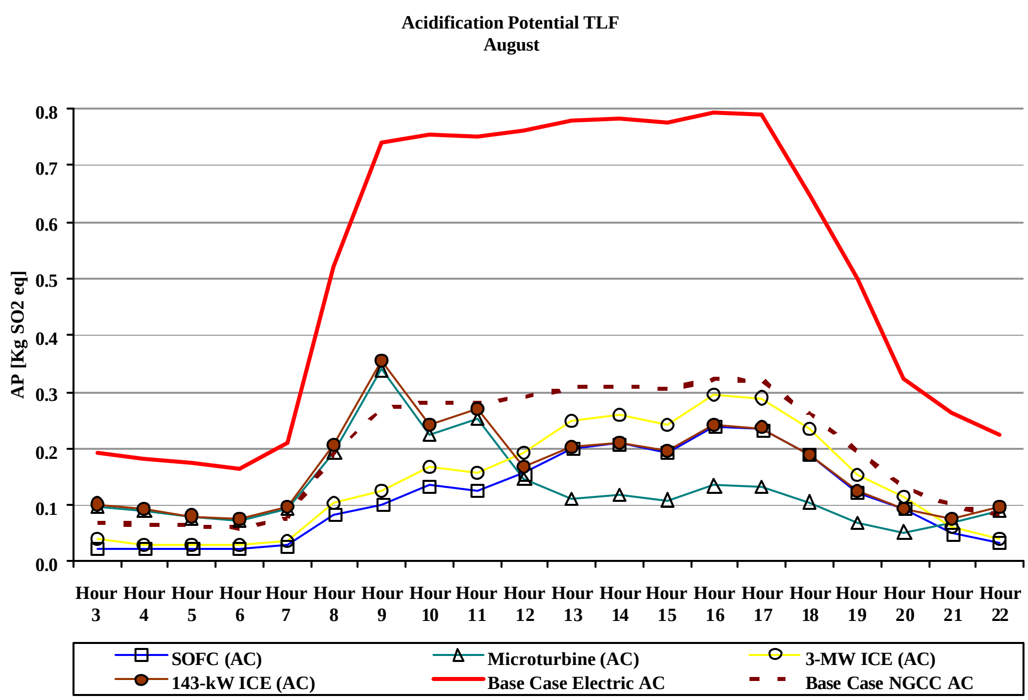

Figure 61: AP during a Typical Day in August (TLF).

4.5 Summary of Results (TLF)

4.5.1 Normalized Curves for Single Environmental Indicators in all Months (TLF)

Figures 62-65 show the normalized graphs used to compare the primary energy consumption, GWP, TOPP, and AP for a typical day in all months.

For TLF scenarios in a typical day in a month, cogeneration processes were operated to meet the thermal load of the building. In a typical day in January, the thermal load of the building consisted mainly of space and water heating (no cooling). In a Typical day in May and August, the thermal load of the building consisted mainly of water heating in addition to cooling. For these scenarios, cooling was met by absorption chillers in May and August. Electric storage was assumed over a typical day in a month and the co-generated electricity from the cogeneration processes met the electric energy use of the building in January, whereas, supplemental electricity from the grid (powered by the average electric generation mix), was used to meet the electric energy use of the building in May and August.

As shown in Figure 62, SOFC (AC) had the highest primary energy consumption in all months (January, May, and August) compared to the other processes. In January, all processes, excluding the SOFC, had similar primary energy consumption, the average electric mix and the 3-MW ICE had approximately equal energy consumption while the NGCC, the microturbine, and the 143-kW ICE had approximately equal energy use. In May, the average electric mix (EC) had the highest energy consumption after the SOFC (AC), followed by the NGCC (EC), whereas, the 143-kW ICE (AC) and the microturbine (AC) had equal energy consumption and the 3-MW ICE (AC) had the lowest energy consumption. In August, the average electric mix (EC) remained the second highest energy consumption process after the SOFC (AC) and comparable to the NGCC (EC) and the 3-MW ICE (AC), while, the 143-MW ICE (AC) and the microturbine (AC) had the lowest energy consumption.

Figure 63 shows the GWP by all processes. Similar to primary energy consumption, SOFC has the highest GWP in all months except in May when it was preceded by the average electric mix. In January, except for SOFC, all cogeneration processes had approximately equal

GWP and comparable to NGCC but slightly less than the average electric. In May, the average electric had the highest GWP and approximately equal to the SOFC followed by the microturbine, which had slightly higher GWP than the NGCC and the 143-kW ICE. In August, the SOFC had the highest GWP followed by the average electric while all the other processes had approximately equal GWP.

Figure 64 shows the TOPP by all processes. The average electric had approximately twice as much TOPP as the other processes in all months. In January, the 3-MW ICE had the second highest TOPP while the microturbine had the lowest TOPP followed by the SOFC; the NGCC and the 143-kW ICE had approximately equal TOPP. However, in May, the 143-kW ICE had the second highest TOPP followed by the microturbine, (which was similar to NGCC), while the SOFC had the lowest TOPP and the 3-MW had the second lower TOPP. Similar to January, in August the 3-MW ICE had the second highest TOPP-similar to the NGCC-while the microturbine had the lowest TOPP followed by the SOFC.

As shown in Figure 65, similar to TOPP, the average electric mix had the highest AP in all months. In January, the NGCC had the second highest AP followed by the 3-MW ICE, the 143-kW ICE which had approximately equal AP to the SOFC while the microturbine had the lowest AP. In May, the 143-kW ICE and the microturbine had the second highest AP followed by the NGCC while the 3-MW ICE and the SOFC had the lowest AP. In August, similar to January, the NGCC had the second highest AP followed by the 3-MW ICE, the 143-kW ICE, which had approximately equal AP to the SOFC while the microturbine had the lowest AP.

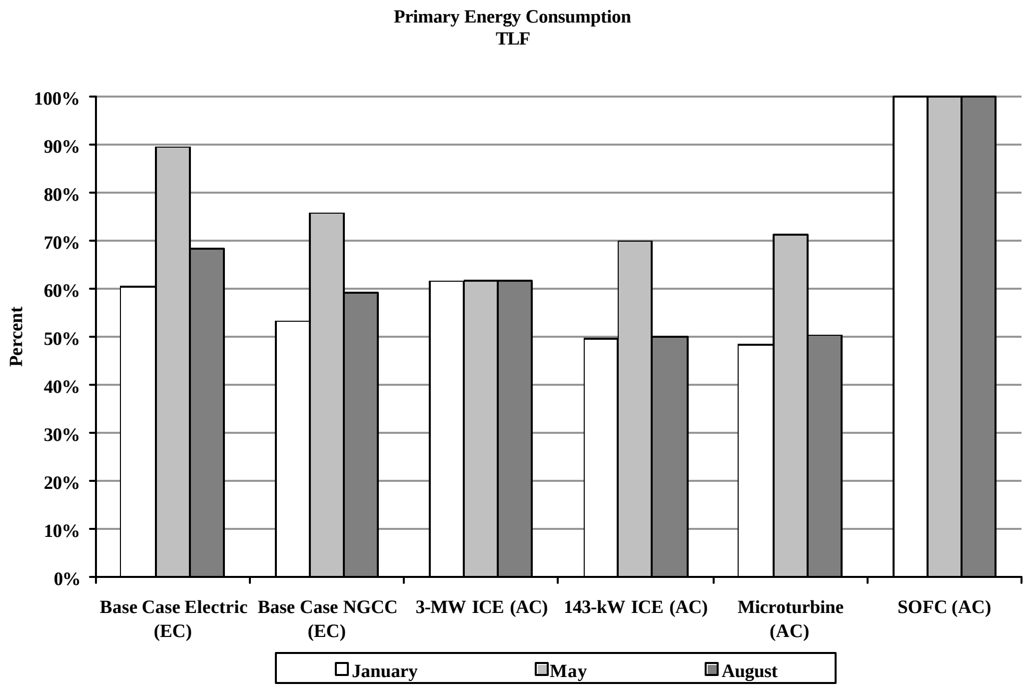

Figure 62: Normalized Primary Energy Consumption for a Typical Day in Each Month (TLF).

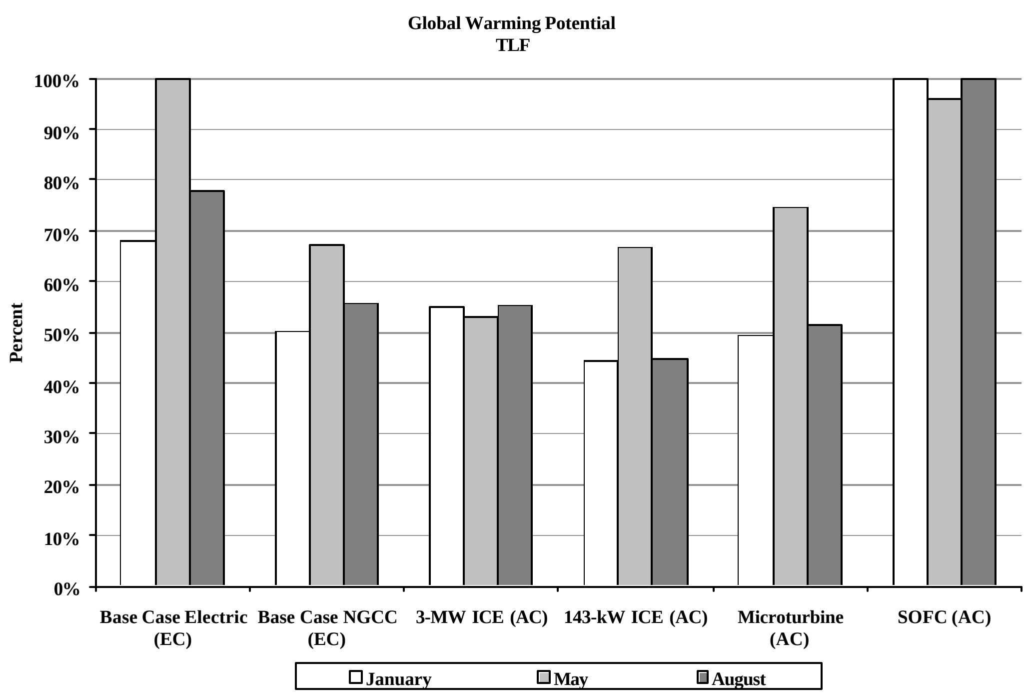

Figure 63: Normalized GWP for a Typical Day in Each Month (TLF).

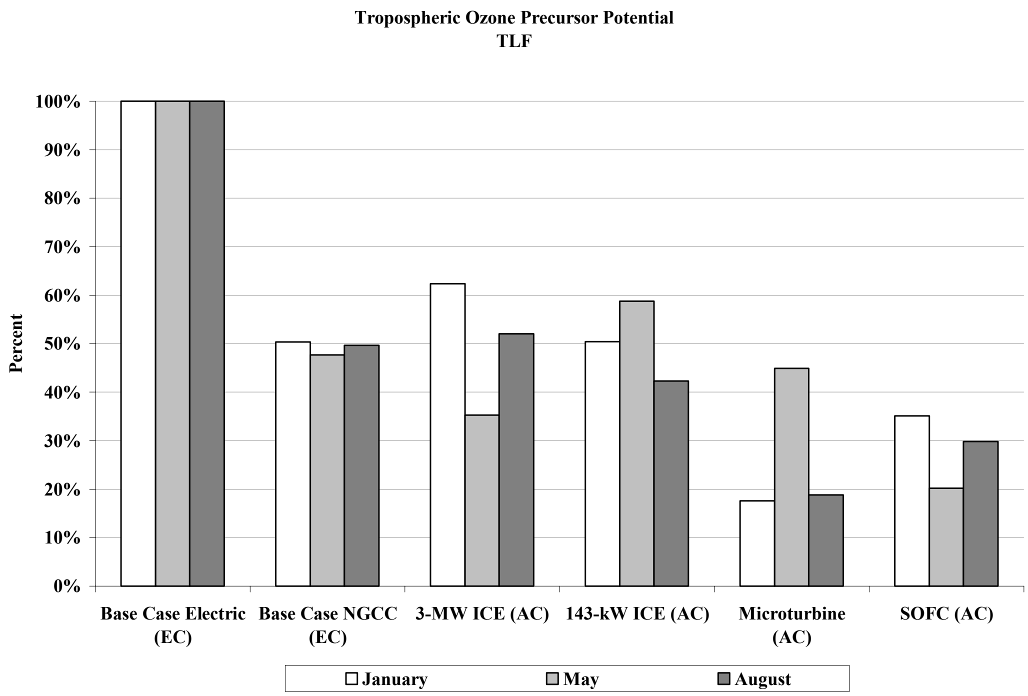

Figure 64: Normalized TOPP for a Typical Day in Each Month (TLF).

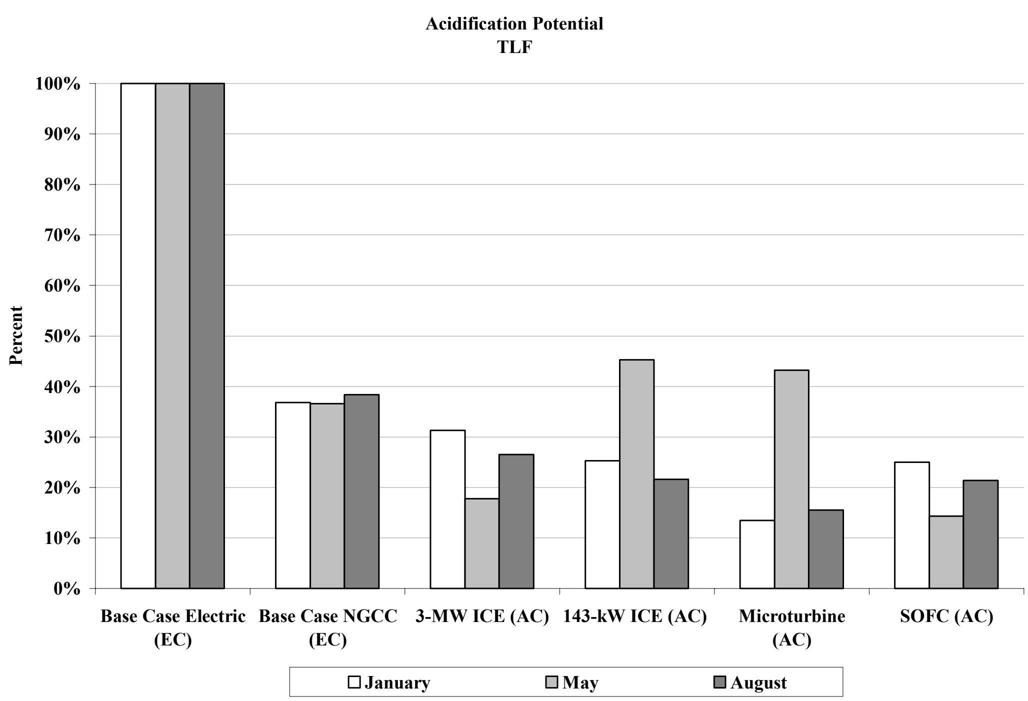

Figure 65: Normalized AP for a Typical Day in Each Month (TLF).

4.5.2 Normalized Curves for All Environmental Indicators in Each Month (TLF)

Figures 66-68 show the normalized graphs used to compare the primary energy consumption, GWP, TOPP, and AP for a typical day in a month. Energy systems scenarios are described in section 4.5.1.

As shown in Figure 66, in a typical day in January, the SOFC had the highest GWP and primary energy consumption while the average electric generation mix had the highest TOPP and AP.

In January, all processes except for the SOFC appeared to have equal energy consumption. Similarly, all processes except the SOFC appeared to have equal GWP although the average electric mix was slightly higher.

When comparing the TOPP in a typical day in January, the 3-MW ICE had the second highest TOPP followed by the NGCC-similar to the 143-kW ICE-while the microturbine had the lowest TOPP followed by the SOFC. When comparing the AP; on the other hand, the NGCC had the second highest AP followed by the 3-MW ICE and the 143-kW which had equal AP as the SOFC while the microturbine had the lowest AP.

As shown in Figure 67, in a typical day in May, SOFC (AC) had the highest energy consumption followed by the average electric mix (EC) and the NGCC (EC) while all the other cogeneration processes had approximately equal energy consumption although the 3-MW ICE (AC) appeared to be slightly lower. The average electric mix had the highest GWP followed by the SOFC while the other processes appeared to have comparable GWP and similar to the NGCC although the 3-MW ICE also appeared to be slightly lower.

As shown in the Figure 67, the average electric had the highest TOPP and AP while the SOFC had the lowest TOPP and AP in May. The 143-kW ICE had the second highest TOPP followed by the microturbine, which had similar TOPP as the NGCC, then the 3-MW ICE and finally the SOFC. The microturbine and the 143-kW ICE had the second highest AP followed by the NGCC and the 3-MW ICE and finally the SOFC.

Figure 68 shows the primary energy consumption and emissions in a typical day in August. The SOFC had the highest energy use and GWP. The average electric mix had the second highest energy consumption and GWP, which were slightly higher than the other cogeneration processes and the NGCC.

As shown in Figure 68, the average electric mix had the highest TOPP and AP. The 3-MW and the NGCC had the second highest TOPP followed by the 143-kW ICE and SOFC while the microturbine had the lowest TOPP. The NGCC had the second highest AP followed by the two ICE processes and the SOFC, while the microturbine also had the lowest AP.

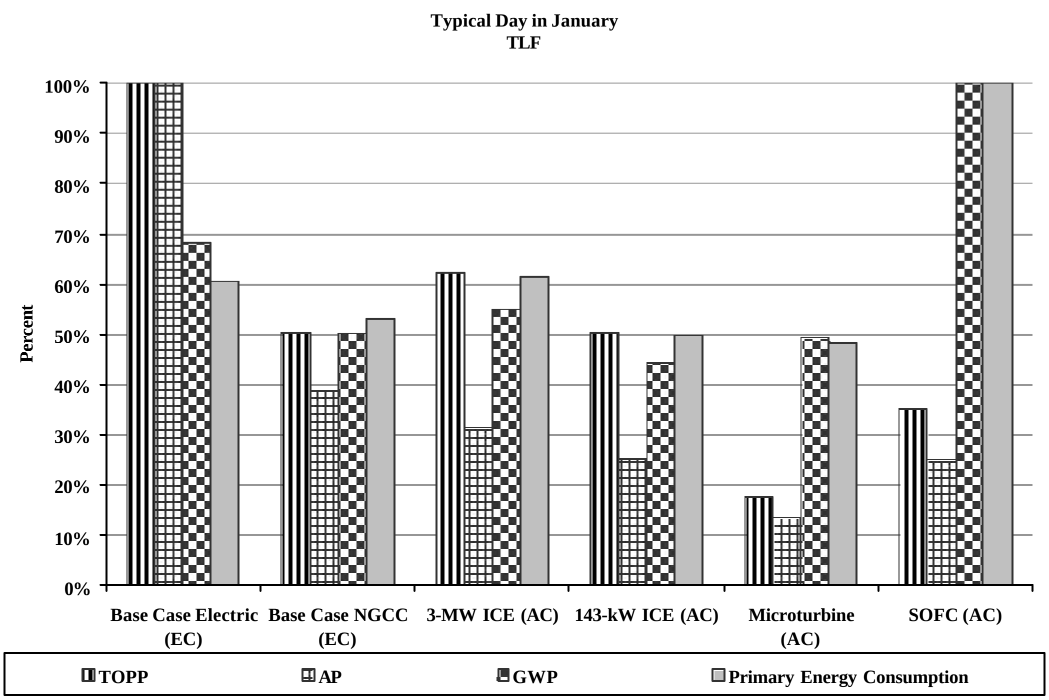

Figure 66: Normalized Primary Energy Consumption and Emissions in a Typical Day in January (TLF).

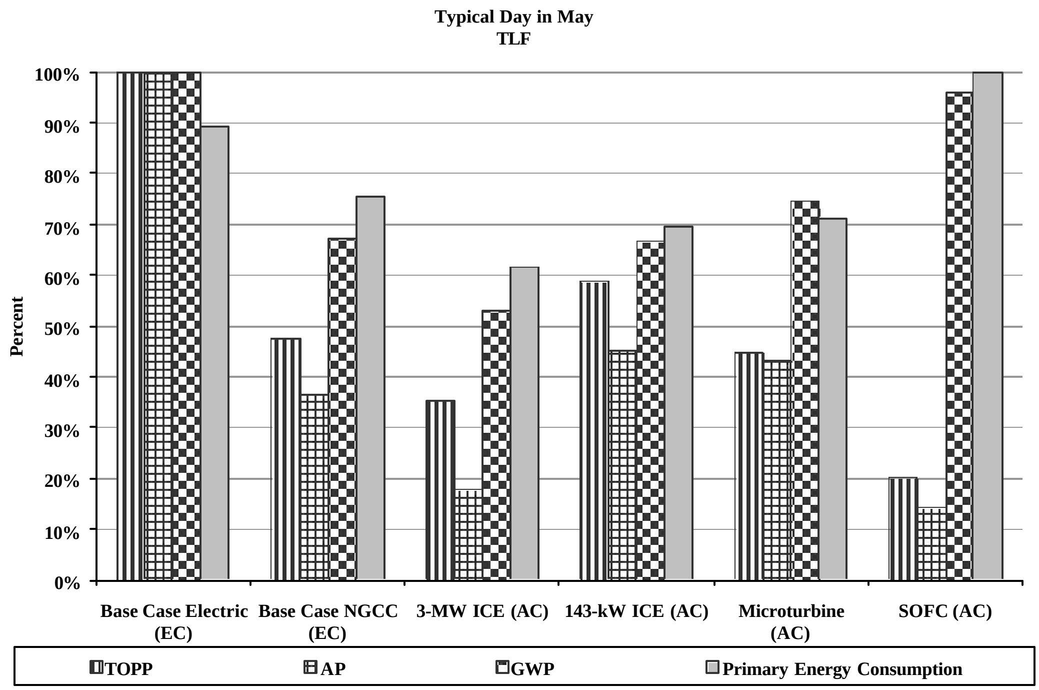

Figure 67: Normalized Primary Energy Consumption and Emissions in a Typical Day in May (TLF).

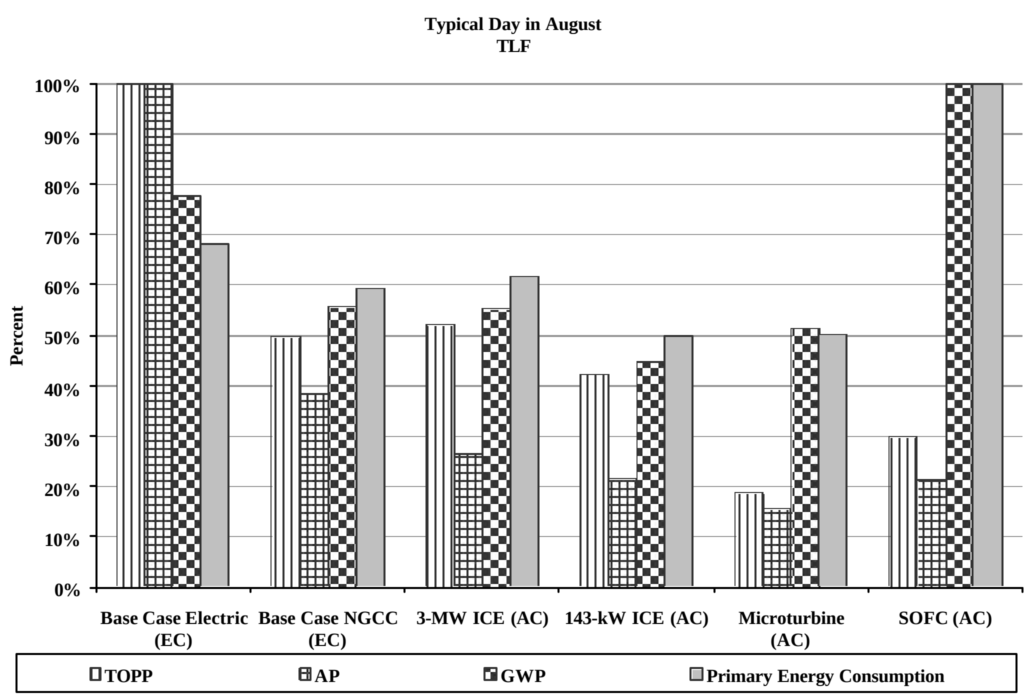

Figure 68: Normalized Primary Energy Consumption and Emissions in a Typical Day in August (TLF).

4.5.3 Summary (TLF)

The analysis of the annual results showed that while following the thermal load of the building, the SOFC, with absorption chiller (AC), produced approximately twice as much electricity as the building's load because of its relatively high electrical efficiency (47%). The 3-MW ICE (AC) was able to meet the electrical load of the building, having an electrical efficiency of 39%, whereas, both the microturbine (AC) and the 143-kW ICE (AC) produced less electrical energy than required by the building because of their low electrical efficiencies (28% and 29%, respectively).

The analysis of the daily electric energy generation (where electric storage was assumed over a typical day in a month) showed that in a typical day in January, while following the thermal load, which consisted mainly of space and water heating and no cooling, all the cogeneration processes produced more electricity than the electric energy use of the building (office equipment and lighting).

For a typical day in a month, the highest electric energy production from all cogeneration processes occurred in January because of the relatively high thermal energy use of the building compared to May and August. As the thermal load decreased from January to May and August, (where the thermal load consisted mainly of water heating), and cooling energy increased, the cogeneration processes with lower electrical efficiency ratio, such as the microturbine and the 143-kW ICE, co-generated insufficient electricity to meet the demand. Consequently, these processes required supplemental electricity to meet the electric energy use of the building.

The hourly electric production from the cogeneration processes (no electric storage was considered over the day) in a typical day in a month followed the thermal energy load profile of the building (refer to Figure 19). The analysis of the hourly electric production from the cogeneration processes showed that electric generation in January was higher during the early and late hours of the day because of the higher thermal load at those hours relative to the working hours of the day. During the working hours (hours 8-17) of the day in January, cogeneration processes with lower electrical efficiency ratios, such as the microturbine and the 143-kW ICE produced less electricity than the electrical use of the building. This mainly because, during those hours the thermal load of the building decreased while the electrical load increased. In May and August, the electric energy generation from the cogeneration processes peaked during the working hours of the day because the cooling energy use increased during those hours; whereas, the electric energy generation was minimal during the early and late hours of the day because the thermal load of the building was low at those hours (water heating).

Generally, the electric energy production from the cogeneration processes, while following the thermal load of the building, corresponded to their respective electrical efficiencies; SOFC produced more electricity than the 3-MW ICE followed by 143-kW ICE and the microturbine; their respective electrical efficiencies are 47%, 39%, 29%, and 28%.

For a typical day in a month analysis, when considering primary energy consumption and GWP in thermal load following cases, the SOFC had the highest energy consumption and GWP in all months compared to other processes. This was partially because of the SOFC's low thermal efficiency ratio (26%) and because no credit was taken for the extra electrical energy produced from the SOFC. Because of the relatively low thermal efficiency ratio, the SOFC was not able to generate thermal energy efficiently by following the thermal demand of the building, i.e., consumed more energy and produced more GWP emissions compared to the other processes. Nevertheless, because of the relatively high electrical efficiency ratio of the SOFC, it co-generated large quantities of electric energy exceeding the electric demand of the building. For example, in January; the SOFC co-generated approximately four times electricity as the demand. In such cases, use could be made of electrical storage or export of electricity to the electric grid. Moreover, carbon dioxide capturing technologies could be used to lower the GWP of the SOFC.

GWP and primary energy consumption from all cogeneration processes followed the process's thermal efficiencies, where the process with the lowest thermal efficiency had the highest GWP and energy consumption. However, in some cases, a process could have high thermal efficiency but had higher energy consumption and GWP than a process with lower thermal efficiency. Generally, this occurred when a cogeneration process, while following the thermal load of the building, failed to meet the electrical load and required supplemental electricity to meet the electrical energy usage of the building. For instance, in a typical day in May, the microturbine and the 143-kW ICE had higher energy consumption and GWP than the

3-MW ICE because they required external electricity from the grid to meet the electrical energy usage of the building, whereas, the 3-MW ICE, although having lower thermal efficiency than both the former processes, had less energy consumption and GWP, because it co-generated sufficient electric energy to meet the demand.

For a typical day in a month analysis, with the exception of the SOFC, which had the highest energy consumption and GWP in all months, all the other cogeneration processes had approximately equal primary energy consumption and GWP, which corresponded to their relatively equal thermal efficiencies: microturbine had a thermal efficiency of 52%, the 143-kW ICE 51%, and the 3-MW ICE 41%. When comparing the cogeneration processes to the average electric generation mix, all cogeneration processes except the SOFC had similar primary energy consumption to the average electric generation mix, however, they (except the SOFC), had lower GWP than the average electric generation mix in all months. Generally, in a typical day in the three months, the NGCC had approximately similar GWP and primary energy consumption to the other cogeneration processes excluding the SOFC.

In a typical day in January, the SOFC had about twice as much primary energy consumption and GWP compared to all other processes. In a typical day in May, the GWP and primary energy consumption of the SOFC was comparable to the average electric mix; whereas, in August, it was higher than the latter

In a typical day in January, the SOFC had more primary energy consumption than the 3-MW ICE, which had similar energy consumption to the average electric mix and the NGCC, followed by the 143-kW and the microturbine. In a typical day in May and August, the GWP and energy consumption of the cogeneration processes were relatively lower than in January. The main reason could be that the heating energy use of the building in January was met by the gas boiler (run by heat from the cogeneration process), which had 89% thermal efficiency, while in May and August the cooling energy use of the building was met by the absorption chiller (run by heat from the cogeneration process), which had 105% thermal efficiency. Hence, the energy conversion was more efficient when using the absorption chiller than the gas boiler resulting in less primary energy consumption. However, the SOFC still remained the highest energy consuming process compared to the other cogeneration processes because of its relatively low thermal efficiency.

The GWP emission distribution from the cogeneration processes was about 90% CO_2, about 10% CH_4, and 0.1-0.06% N_2O (depending on the process). The CO_2 emissions from the 143-kW ICE, the 3-MW ICE, and the microturbine originated primarily from the cogeneration combustion processes, when no supplemental electricity was required. However, when the electric energy produced from the cogeneration processes was not sufficient to meet the electric energy use of the building and supplemental electricity from the average electric mix was required, some of the CO_2 emissions originated from upstream electric generation processes associated with the average electric mix. The CH_4 emissions originated mainly from upstream processes, such as gas extraction, distribution, and processing. With both the ICE cogeneration processes, most of the N_2O emissions originated from the cogeneration combustion process. The combustion processes of the microturbine and the SOFC produced negligible N_2O emissions, and all the N_2O emissions originated from upstream electric and thermal generation processes.

When considering TOPP and AP, all the cogeneration processes including the NGCC were better alternatives to the average electric generation mix mainly because they used natural gas as primary fuel, which has very low nitrogen and sulfur content compared to other fuels used in the average electric mix, such as coal.

In a typical day in January, although the SOFC had the highest GWP and primary energy consumption compared to the other processes, its TOPP and AP were relatively low. The microturbine had the lowest TOPP and AP in January compared to the other processes, whereas, the average electric mix had the highest TOPP and AP. The 143-kW ICE and the 3-MW ICE had the highest TOPP and AP when compared to the other cogeneration processes but similar to the NGCC.

Although the microturbine had lower TOPP than the SOFC in January, most of the TOPP and AP emissions originated from the microturbine cogeneration combustion process, whereas, the majority of the TOPP and AP emissions with the SOFC originated from the gas turbine compressor and other upstream processes. Both the 143-kW and the 3-MW ICE had relatively high TOPP in January because of the relatively high carbon monoxide content in their emissions compared to the microturbine and the SOFC.

In a typical day in May, the SOFC had relatively lower TOPP and AP than the microturbine while in August, it was higher. This was because the microturbine required more supplemental electricity in May than in August, and hence the difference in TOPP and AP was mainly due to the supplemental electricity from the average electric mix. Similarly, in May, the 143-kW ICE required supplemental electricity to meet the electric demand of the building, which explained its relatively higher TOPP and AP compared to the other cogeneration processes. The 143-kW ICE had lower TOPP and AP than the 3-MW ICE in August, which reflected the impact of thermal efficiencies on their emissions (the 143-kW ICE had higher thermal efficiency than the 3-MW ICE). Similar to January, the NGCC had similar TOPP and AP to the 143-kW ICE and the 3-MW ICE, especially when no supplemental electricity was required to meet the electric demand of the building, as was the case in August.

Generally, there were some differences between the annual and daily energy consumptions and emissions from the cogeneration processes. For instance, the 3-MW ICE had the lowest annual primary energy consumption and GWP when compared to the other processes but this was not the case when analyzing the daily primary energy consumption and GWP from the cogeneration processes, where it had higher energy consumption and GWP in January and August. Similarly, the SOFC (AC) had the lowest annual TOPP and AP compared to the other processes but when comparing the daily results, the SOFC (AC) had higher TOPP and AP than the microturbine in January and August.

Hence, in thermal load following cases, while the thermal efficiency ratio of a process was an important factor in predicting the primary energy consumption and emissions from a process, the electrical efficiency of a process determined if a cogeneration process was a practical option because the resulting co-generated electricity from the processes could be insufficient to meet the electrical load of the building and supplemental electricity might be required to meet the demand.

5.0 ENVIRONMENTAL IMPACT ANALYSIS OF ENERGY USE IN BUILDINGS (ELF)

In this chapter, the cogeneration processes were operated to follow the electrical load of the building, consisting of office equipment, lighting, and cooling, and their primary energy consumption and emissions are compared to that from average electric generation mix and natural gas combined cycle. Average electric mix and NGCC systems met the electric energy use of the building including cooling with electric chillers and met the heating energy use with gas boilers.

The chapter contains the following sections:

Section 5.1: Primary Energy Consumption (ELF)

Section 5.1.1: Annual Primary Energy Consumption Analysis (ELF)

Section 5.1.2: Typical Day in a Month Primary Energy Consumption Analysis (ELF)

Section 5.1.3: Hourly Primary Energy Consumption in a Typical Day in a Month Analysis (ELF)

Section 5.2: Global Warming Potential (GWP) (ELF)

Section 5.2.1: Annual GWP Analysis (ELF)

Section 5.2.2: Typical Day in a Month GWP Analysis (ELF)

Section 5.2.3: Hourly GWP in a Typical Day in a Month Analysis (ELF)

Section 5.3: Tropospheric Ozone Precursor Potential (TOPP) (ELF)

Section 5.3.1: Annual TOPP Analysis (ELF)

Section 5.3.2: Typical Day in a Month TOPP Analysis (ELF)

Section 5.3.3: Hourly TOPP in a Typical Day in a Month Analysis (ELF)

Section 5.4: Acidification Potential (AP) (ELF)

Section 5.4.1: Annual AP Analysis (ELF)

Section 5.4.2: Typical Day in a Month AP Analysis (ELF)

Section 5.4.3: Hourly AP in a Typical Day in a Month Analysis (ELF)

Section 5.5: Summary of Results (ELF)

The section provides a summary of the environmental impact indicators used in the study and includes normalized curves of the environmental indicators studied for a typical day in a month used to present comparisons between the energy systems analyzed. The normalized curves are given in the following sub-sections:

Section 5.5.1: Normalized Curves for Single Environmental Indicators in all Months (ELF)

Results from each environmental indicator are normalized for a typical day in January, May, and August to compare the performances of all the energy systems examined.

Section 5.5.2: Normalized Curves for All Environmental Indicators in Each Month (ELF)

Results from all environmental indicators are normalized in one graph for each typical day in January, May, and August to compare the performances of all the energy systems examined.

Section 5.5.3: Summary (ELF)

The section provides a summary of the results in the chapter.

The calculations performed in order to obtain the data for the model are given in Chapter 2.

Note that the energy systems referred to in this chapter, (the average electric mix, NGCC, SOFC, microturbine, 143-kW ICE, and 3-MW ICE) are a group of linked processes used to meet the thermal and electric load of the building. For example, a 'microturbine' could be the cogeneration process in addition to a chiller, a boiler, supplemental electricity from average electric mix, upstream processes, such as resource extraction, transportation etc. A breakdown of the processes used to construct the scenarios, including tables of data inputted into the software, is given in Appendix G. The basic process trees used in the model are given in Appendix J.

Tables of primary energy consumption and emissions from the energy generation systems (output from GEMIS) studied are given in Appendix H.

5.1 Primary Energy Consumption (ELF)

5.1.1 Annual Primary Energy Consumption Analysis (ELF)

In two options representing conventional practice, the NGCC and the average electric mix systems met the electric energy use of the building, consisting of mainly of office equipment, lighting, and cooling with electric chillers, and used gas boilers to meet the space and water heating. On the other hand, in one option, the cogeneration processes generated electric energy to meet the electric load of the building (office equipment, lighting, and ventilation and cooling) and the co-generated heat was used for space and water heating. Another option was that the cogeneration processes generated electric energy to meet the electric load of the building excluding cooling, and used absorption chillers (driven by heat from cogeneration processes), for cooling. The co-generated heat from the cogeneration processes was also used to meet part or all of the space and water heating (gas boilers). If any supplemental heat was required, it was met by gas boilers.

With cogeneration processes that used EC for cooling, while following the electric load of the building, the primary energy consumption by the cogeneration processes, corresponded to their electrical efficiencies. Processes with high electrical efficiencies consumed less energy than those with lower ones. All the cogeneration processes using EC fulfilled the thermal requirements of the building without the need for supplemental heat. All cogeneration processes using AC for cooling had lower primary energy consumption than when using EC except for the SOFC, where the opposite is true. This was mainly because the relatively low thermal output from the SOFC was not used efficiently in running the AC, on the contrary, the high electric output from the SOFC (due to its high electric efficiency) was used more effectively in running the EC for cooling.

As shown in Figure 69, when comparing cogeneration systems, the SOFC (EC) had the lowest primary energy consumption, followed by the 3-MW ICE (EC), the 143-kW ICE (EC), and the microturbine (EC). For cogeneration systems using AC for cooling, the same sequence of performance applies except that SOFC (AC) had the highest primary energy consumption.

The NGCC (EC) had similar primary energy consumption to the 3-MW ICE (there was not significant difference between the 3-MW ICE using EC and AC for cooling). The average electric mix (EC) had comparable but slightly lower energy consumption to the microturbine and the 143-kW ICE processes but higher energy consumption than the 3-MW ICE (AC and EC) and the NGCC (EC). The SOFC (EC) had the lowest primary energy consumption compared to all processes.

With cogeneration processes that used AC for cooling, the primary energy consumption by the cogeneration processes did not correspond to their electric efficiencies because part of the load was supplied by AC, which takes into account the thermal efficiencies of the processes. Although the SOFC had the highest electrical efficiency relative to the other cogeneration processes, the SOFC (AC), had the highest primary energy consumption because of its lower thermal efficiency ratio, and required supplemental heat to meet the thermal energy use of the building. However, the SOFC (EC) was able to co-generate sufficient heat to meet the thermal energy use of the building. Similarly, all the other cogeneration systems with AC as well as EC were able to co-generate sufficient thermal energy to meet the thermal load of the building.

Generally, cogeneration efficiencies were more of a determinant of performance in the annual analysis than the COP's of the EC and AC. There was no marked difference between the uses of AC versus EC with the 3-MW ICE because its thermal and electrical efficiency ratios were close, 41% and 39%, respectively, and hence the energy utilization was approximately equal. However, there was considerable difference between the use of AC and EC with the other cogeneration processes because the difference between their thermal and electrical efficiency ratios was large. Refer to Table 6 for cogeneration systems efficiencies.

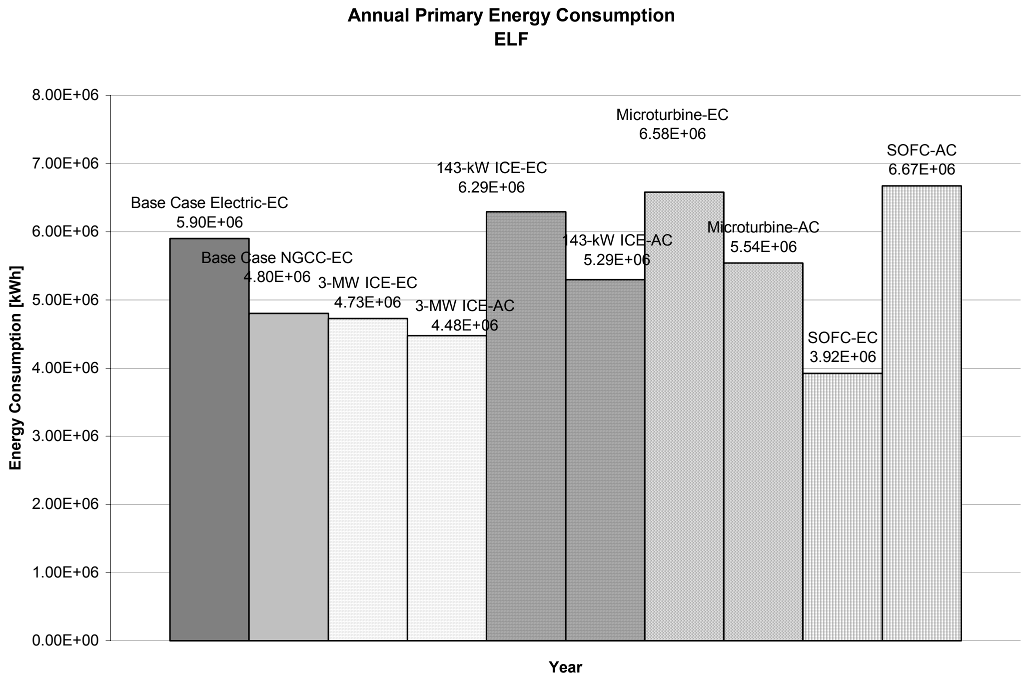

Figure 69: Annual Primary Energy Consumption (ELF).

5.1.2 Typical Day in a Month Primary Energy Consumption Analysis (ELF)

January

For a typical day in January, the cogeneration systems were operated to meet the electric energy use of the building, consisting mainly of equipment and lighting, and the co-generated heat was used to meet part of the thermal energy demand of the building. Although thermal storage was assumed over the day, all cogeneration processes required supplemental heat (from gas boilers) to meet the space and water heating energy use of the building. Average electric generation mix and NGCC systems were used in two scenarios to provide electricity for the building electric energy use (equipment and lighting and cooling with electric chillers) and heating with gas boilers.

As shown in Figure 70, in January, all the cogeneration processes consumed approximately the same quantities of primary energy. The NGCC had the second highest energy consumption and the average electric mix had the highest primary energy consumption.

May & August

In a typical day in May and August, the cogeneration systems were operated to follow the equipment, lighting, and cooling energy use of the building, in one option; and to follow the equipment and lighting energy use of the building in another option. In the first option, cooling was met by electric chillers (EC), whereas, in the second option, cooling was met by a combination of absorption and electric chillers (AC/EC). The cogeneration systems were further operated, if supplemental cooling energy was required. In addition to driving the AC, the co-generated heat from the cogeneration processes was also used to meet the heating energy use of the building (mainly water heating), as all cogeneration systems were able to meet the heating demand on these months. Average electric generation mix and NGCC were used similar to January.

As shown in Figures 71 and 72, in the summer months (May and August), (cogeneration processes using electric chiller only), the microturbine and the 143-kW ICE consumed more energy than the average electric (EC) because of their low electrical efficiencies. The 3-MW

ICE and the average electric mix had comparable energy consumption while the SOFC and the NGCC had the lowest energy consumption.

In May and August, when cogeneration processes utilized the co-generated heat by running absorption chillers, their energy consumption was reduced significantly. Energy consumption by both the microturbine and the 143-kW ICE using a combination of AC and EC was reduced significantly and became comparable to that consumed by the average electric (EC). Likewise, energy consumption by the 3-MW ICE as well as the SOFC was reduced and became comparable to the NGCC.

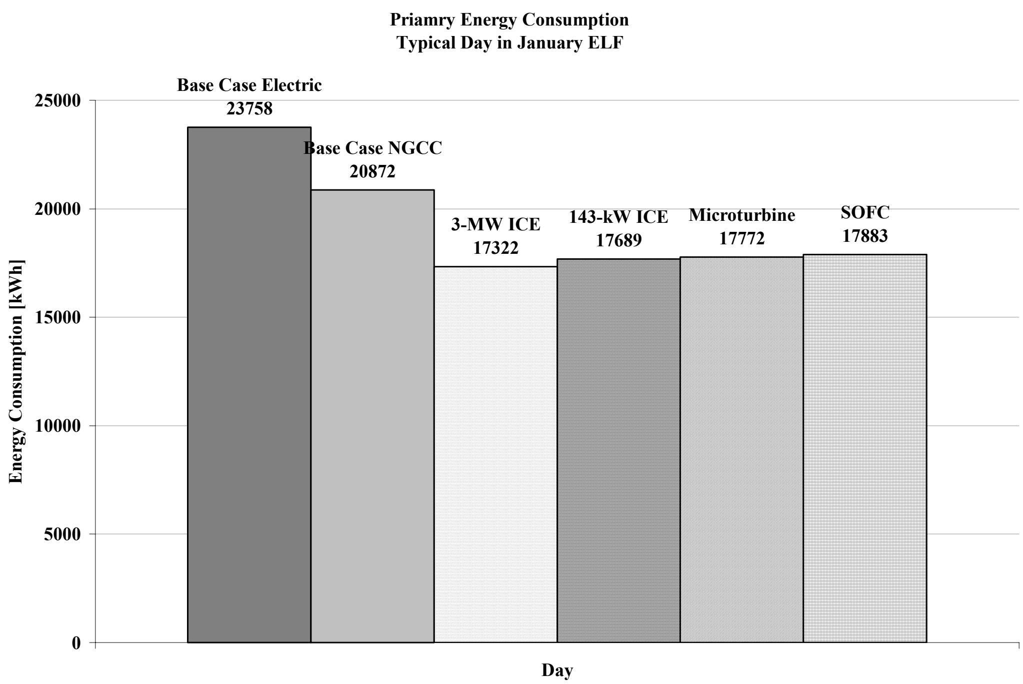

Figure 70: Primary Energy Consumption in a Typical Day in January (ELF).

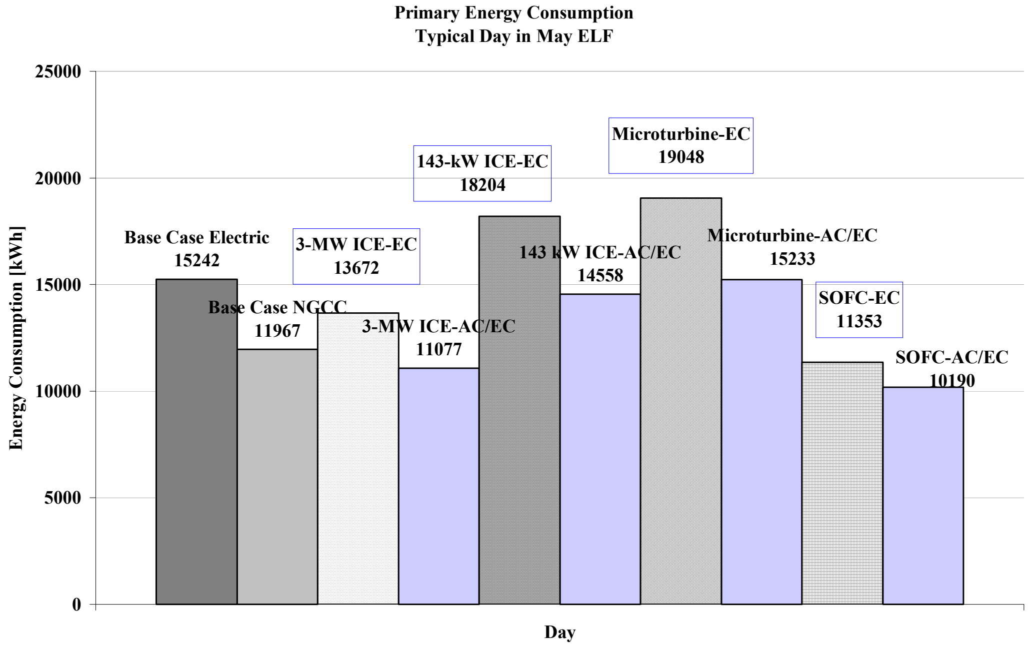

Figure 71: Primary Energy Consumption in a Typical Day in May (ELF).

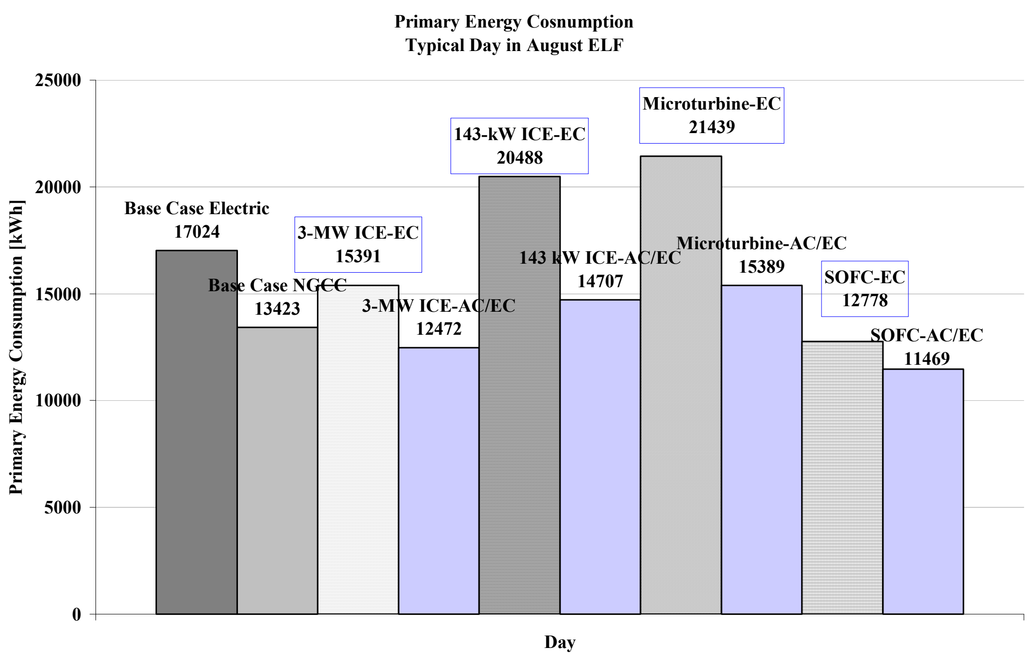

Figure 72: Primary Energy Consumption in a Typical Day in August (ELF).

5.1.3 Hourly Primary Energy Consumption Analysis (ELF)

January

For hourly scenarios, energy systems were operated similarly to daily scenarios, described in the previous sections. The main difference is that thermal storage was not considered over the day, i.e., if supplemental heat was required, it was provided on hourly basis.

As shown in Figure 73, in January, the energy consumption profile followed the thermal load curve when the processes failed to meet the thermal load but followed the electric load when a gas boiler was required to meet the thermal demand. Refer to Figure 18 and Figure 19 for electrical and thermal load profiles. Although there was a difference in energy consumption profile during the working hours of the day, energy consumption was approximately equal for all cogeneration processes when summed over the day.

At the beginning and end of the day, all cogeneration processes co-generated less heat than required while following the thermal load of the building and consumed similar energy. During the working hours of the day, when the electric energy use of the building increased and the thermal use relatively decreased, the SOFC and the 3-MW ICE had the lowest energy consumption, whereas, the 143-kW ICE and microturbine had higher energy consumption. This was mainly because the SOFC and the 3-MW ICE had higher electrical efficiencies than the 143-kW ICE and the microturbine. However, because the SOFC and the 3-MW ICE, both having lower thermal efficiency ratios, they co-generated less heat than that required by the building, and hence, needed supplemental heat from the gas boiler to meet the demand.

During all hours of the day, the average electric mix had the highest energy consumption when compared to the other processes and the NGCC had the second highest energy consumption during most hours of the day.

May & August

In May and August, the energy consumption profile followed the electric load profile when no supplemental heat was required to meet the thermal energy use of the building; however, when the cogeneration processes failed to meet the thermal energy use, the energy use profile followed the thermal energy use curve of the building (refer to Figures 18 and 19). The energy consumption of the processes corresponded to their electrical efficiencies; processes with higher electrical efficiency had lower energy use. For instance, as shown in Figure 74, in May, the SOFC had the lowest energy use followed by the 3-MW ICE (using a combination of AC and EC), which had similar energy consumption as the NGCC, followed by the microturbine (AC and EC) and the 143-kW ICE (AC and EC), where both had similar energy consumption to the average electric mix.

When cogeneration processes uses a combination of absorption and electric chillers instead of electric chillers alone, the energy consumption was reduced significantly as shown in Figure 74 and 75.

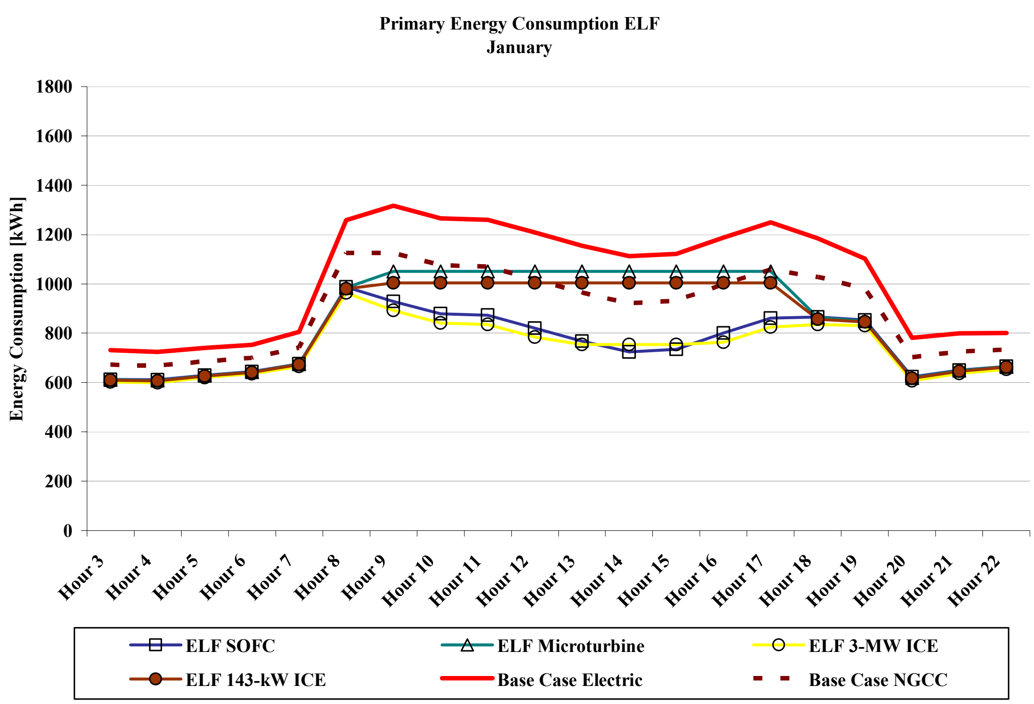

Figure 73: Primary Energy Consumption during a Typical Day in January (ELF).

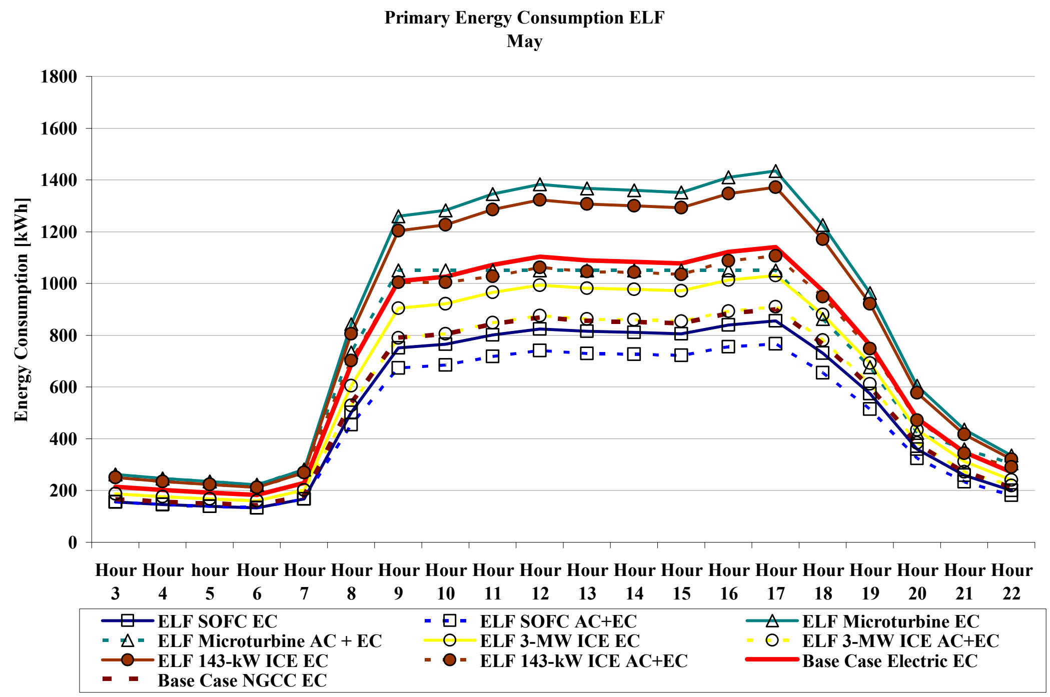

Figure 74: Primary Energy Consumption during a Typical Day in May (ELF).

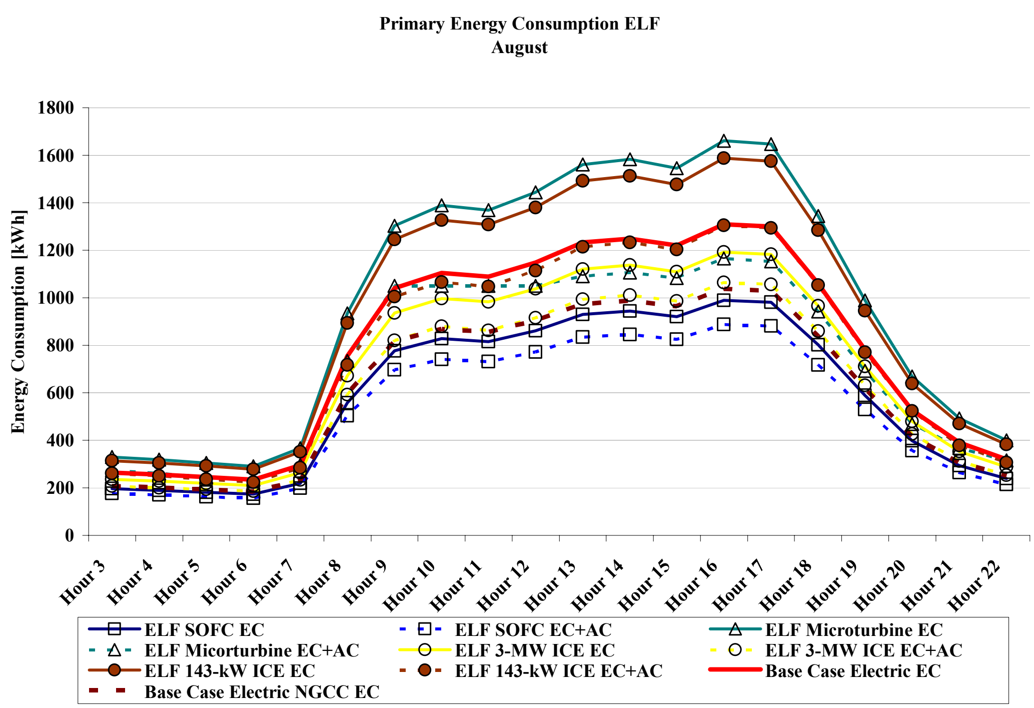

Figure 75: Primary Energy Consumption during a Typical Day in August (ELF).

5.2 Global Warming Potential (GWP) (ELF)

5.2.1 Annual GWP Analysis (ELF)

As shown in Figure 76, the annual GWP emission profile resembles the annual primary energy consumption shown in Figure 69. Refer to explanation given in the annual primary analysis (ELF) section for rationale. The main exception between the annual primary energy consumption and the GWP was that the average electric mix had the highest GWP compared to all other processes, whereas, with the primary energy consumption, some of the processes had more primary energy consumption than the average electric (EC).

The annual GWP emission distribution from the 3-MW ICE (EC), as well as from the 143-kW ICE (EC), was about 89% CO_2 (95% of the CO_2 originated from the cogeneration combustion process, 2.5% from the gas turbine compressor, and the rest from upstream processes), 10% CH_4 (45% from gas extraction, 29% from gas processing, 15% from the cogeneration combustion process, 9% from gas pipelines, and the rest from coal extraction and other upstream processes), and 0.9% N_2O (92% from the cogeneration combustion process, 6% from gas turbine compressor, and the rest from other upstream processes).

The GWP emission distribution from the 3-MW ICE (AC) was similar to the 3-MW ICE (EC) but the difference was in the sources of emissions. As the 3-MW ICE (AC) required supplemental thermal energy to meet the cooling load of the building, some of the GWP emissions originated from process associated with producing that supplemental thermal energy. About 84% of the CO_2, as well as the N_2O emissions, originated from the cogeneration combustion process used for electric energy generation and 10% of the emission was from the combustion process used for supplemental thermal energy generation. With CH_4 emissions, 13% of the emissions originated from the cogeneration combustion process used for electric energy generation and 2% for thermal energy generation.

The GWP emission distribution from the microturbine (EC), as well as the microturbine (AC), was 92% CO_2 (96% from the cogeneration combustion process, 2% from the gas turbine compressor, and the rest from other processes), 7% CH_4 (87% from gas extraction and processing, 11% from gas pipelines, and the rest from other upstream processes), and 0.062% N_2O (75% from gas turbine compressor, and the rest from other upstream processes).

The GWP emission distribution from the SOFC (EC) was 92% CO_2 (mainly from natural gas reforming to hydrogen gas), 8% CH_4 (majority from gas extraction and processing operations and about 11% from gas pipelines), and 0.064% N_2O (74% from gas turbine compressor and the rest from other upstream processes). The GWP emission distribution from SOFC (AC) was similar to that of SOFC (EC) but there was a slightly higher percentage of N_2O, about 0.096%, most of which originated from the gas turbine compressor.

Refer to section 4.3.1 for GWP emission distribution from average electric mix and NGCC.

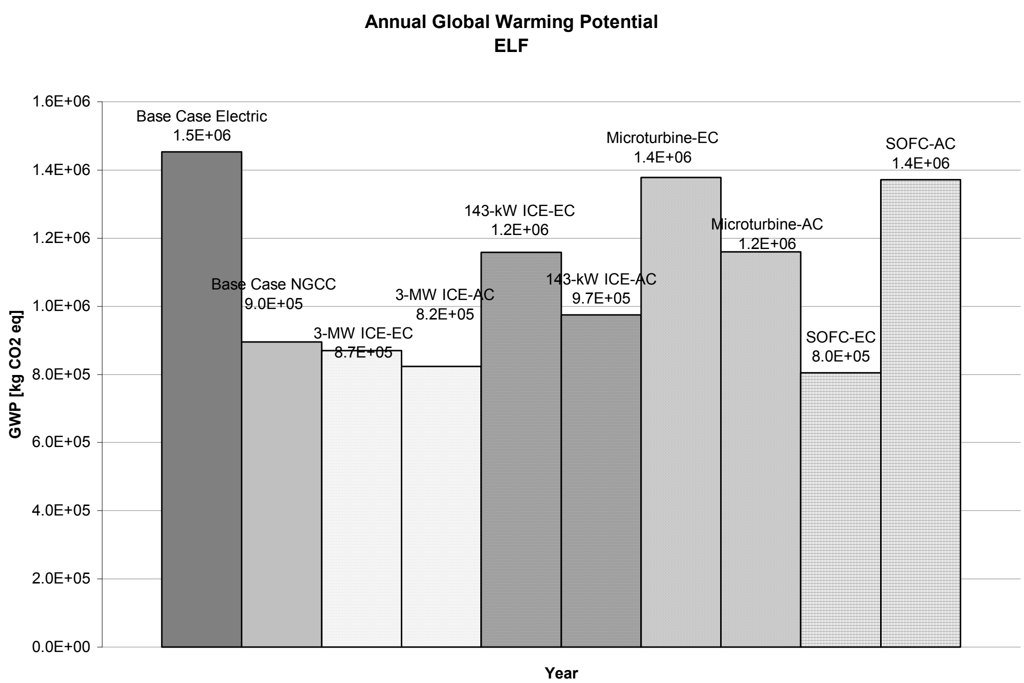

Figure 76: Annual GWP (ELF).

5.2.2 Typical Day in a Month GWP Analysis (ELF)

January

While following the electric load, all alternatives produced higher GWP emissions in a typical day in January compared to the summer months, mainly because of the higher thermal energy use and; hence, higher emissions mainly from the gas boiler. As shown in Figure 77, all the cogeneration processes produced approximately equal GWP emissions. The NGCC produced slightly higher emissions than the other cogeneration processes, while the average electric mix produced the highest emissions compared to that from the other processes.

In a typical day in January, both ICE cogeneration processes produced approximately equal GWP emission distribution: 90% CO_2, 10% CH_4, and about 0.8% N_2O. However, the origins of the emissions differed. About 60% of the carbon dioxide emissions from the 3-MW ICE originated from the cogeneration combustion process and 36% of the carbon dioxide emissions originated from the gas boiler. On the other hand, about 80% of the carbon dioxide emissions from the 143-kW ICE originated from the cogeneration combustion process and about 15% of the emissions originated from the gas boiler. This was because the 3-MW ICE co-generated less heat while following the electric load, and hence, required supplemental thermal input from the gas boiler to meet the thermal energy use of the building. On other hand, the 143-kW ICE, having a higher thermal efficiency, did not require as much supplemental heat as that required by the 3-MW ICE. The 143-kW ICE produced higher GWP emissions because of its lower electrical efficiency.

The SOFC had comparable GWP emissions to other cogeneration processes although slightly lower, mainly because, while following the electric load, it produced less heat than that required by the building because of its low thermal efficiency. About 45% of the carbon dioxide emissions originated from the gas boiler, which was used to satisfy the thermal energy use, and the remaining from gas reforming processes. However, the SOFC produced much lower N_2O than the other cogeneration units. About 0.1% of the GWP emissions from the SOFC were N_2O while other cogeneration processes produced about 0.8%. Half of the N_2O emissions from the SOFC originated from the gas boiler and the remaining from gas reforming processes while the

N_2O emissions from the ICE processes originated mostly from the cogeneration combustion processes. N_2O emissions from the microturbine process originated mostly upstream, from coal and gas steam turbines and 18% of the N_2O was from the gas boiler.

The GWP emission distribution of the NGCC was about 91% CO_2, 8% CH_4, and 0.5% N_2O. About 50% of the carbon dioxide emissions originated from the gas boiler and 50% from the NGCC. About 69% of N_2O emissions originated from the NGCC and about 17% from the boiler. The GWP emission distribution from the average electric mix was about 93% CO_2 (40% of the CO_2 emissions are from gas boiler), 6% CH_4, and 1% N_2O (5% of the N_2O emissions was from gas boiler).

May & August

In May and August, while the cogeneration processes followed the electric load, they co-generated large quantities of heat but there was limited utilization of the thermal energy because of the relatively low thermal energy use of the building. As shown in Figure 78 and 79, during a typical day in May and August, the GWP emissions from all processes, using EC only, followed the same profile, although August had higher emissions because of the higher cooling and electric load. GWP emissions from the cogeneration processes using EC only followed the processes electrical efficiencies, i.e., processes with high electrical efficiencies produced less GWP emissions than those with lower efficiencies: NGCC produced the least emissions followed by the SOFC, then the 3-MW ICE, the 143-kW ICE, the average electric mix, and finally the microturbine.

The NGCC, the SOFC, and the 3-MW ICE had comparable GWP emissions while the microturbine produced twice the GWP emission and was comparable to the 143-kW ICE and the average electric mix.

However, when using a combination of AC and EC, where the thermal energy was utilized in the AC for cooling, the GWP emissions from all cogeneration processes were reduced significantly. All the processes had comparable GWP emissions but lower than the average electric mix.

The GWP emission distribution of both the 143-kW ICE and the 3-MW ICE was 89% CO_2, 10% CH_4, and 0.9% N_2O. Most of the CO_2 and N_2O emissions originated from the ICE cogeneration processes.

The GWP emission distribution from the microturbine was about 92% CO_2 (most of which was from the cogeneration combustion process), 7% CH_4, and 0.06% N_2O (mainly from upstream electric generation processes). The GWP emission distribution from the SOFC was 92% CO_2, (most of which from the gas reforming processes), 8% CH_4, and 0.06% N_2O. These percentages were the same for both May and August and they were the same whether using cogeneration processes with an electric chiller only or with a combination of absorption and electric chillers because the SOFC had low thermal efficiency, it produced relatively less heat for the absorption chiller.

NGCC had low GWP emissions because of its high electric efficiency (49%) compared to the other cogeneration processes; the highest of which was the SOFC with electrical efficiency of 47%. The GWP emission distribution of the NGCC was 90% CO_2, 9% CH_4, and 0.8% N_2O. Most of the NGCC CO_2 and N_2O emissions (about 90%) originated from the combined cycle process, unlike in January, when about 55% of the GWP emissions originated from the NGCC. The GWP emission distribution from the average electric mix was similar to January.

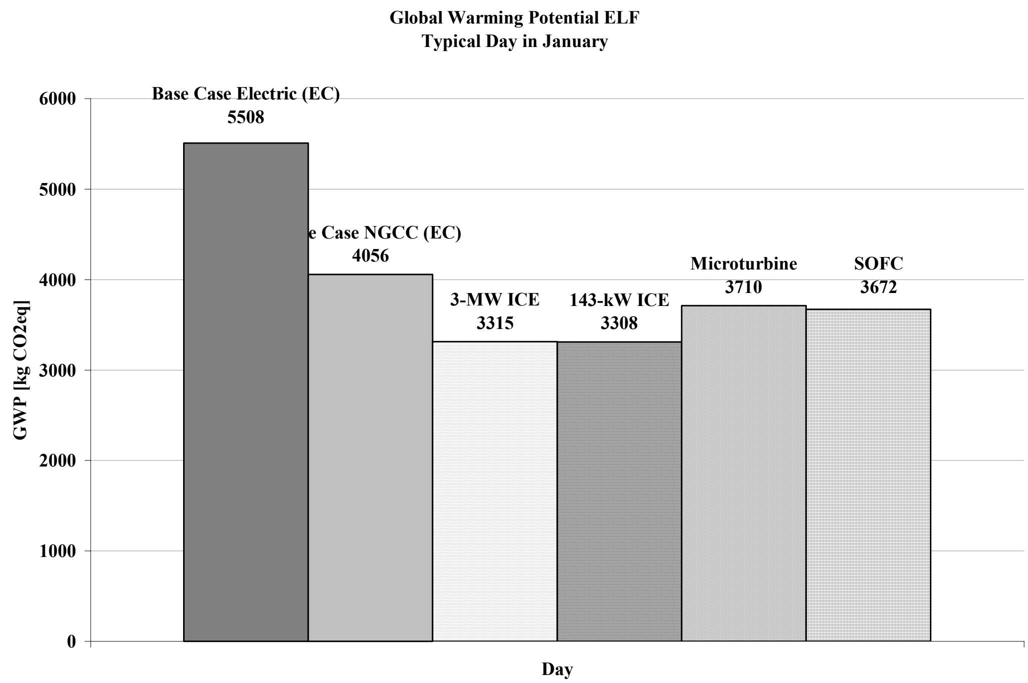

Figure 77: GWP in a Typical Day in January (ELF).

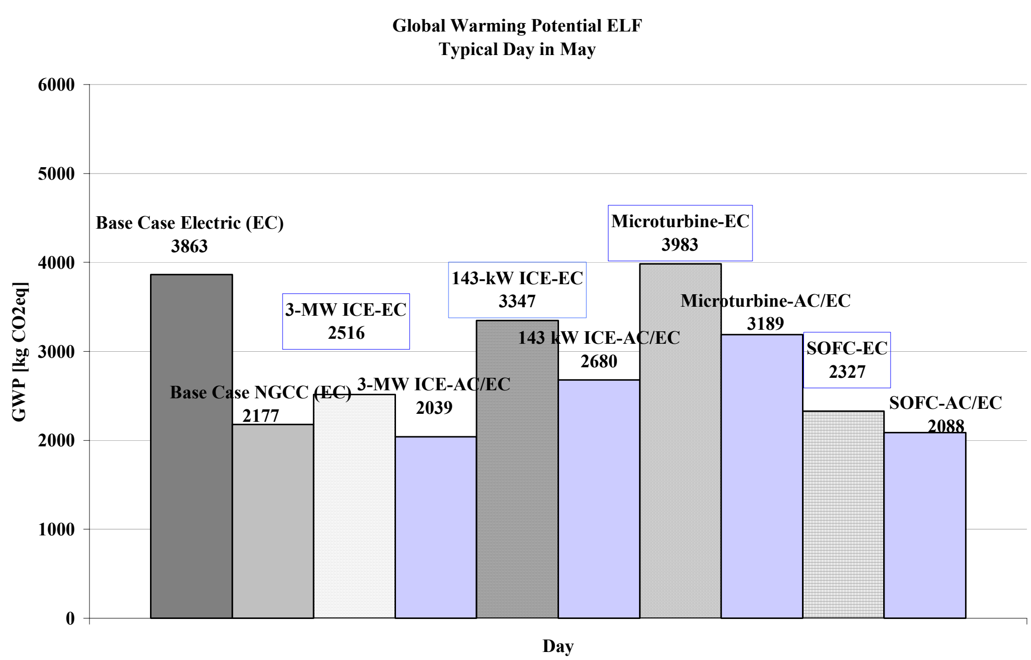

Figure 78: GWP in a Typical Day in May (ELF).

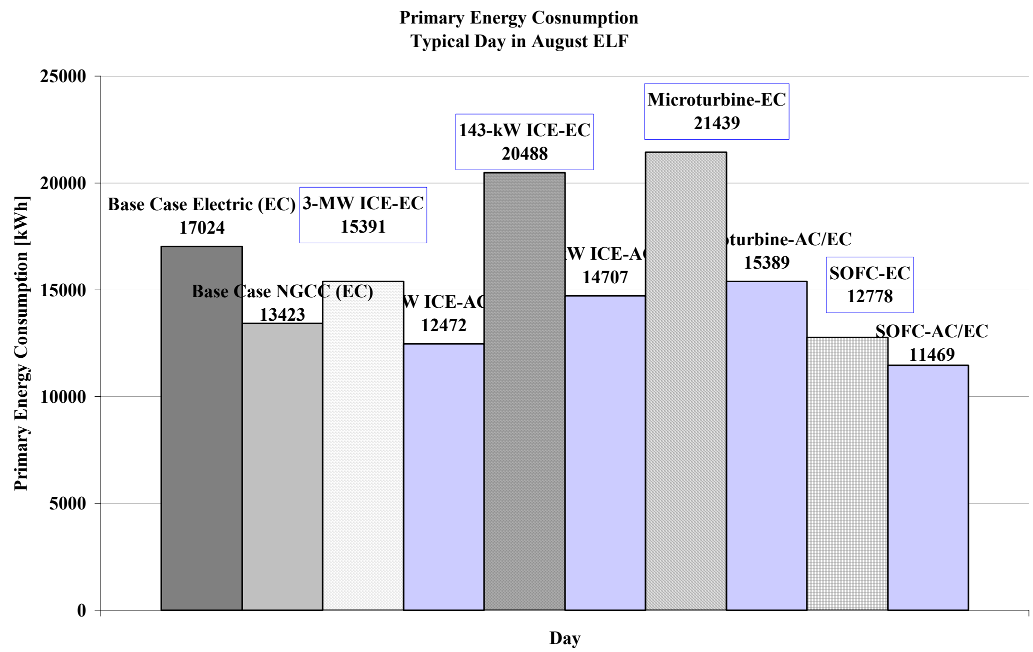

Figure 79: GWP in a Typical Day in August (ELF).

5.2.3 Hourly GWP Analysis (ELF)

January

The GWP emission profile followed the thermal energy use curve of the building when the processes failed to meet the thermal load and required supplemental heat; however, when the processes produced excess heat, their emission profile followed the electric energy use curve, refer to Figure 18 and Figure 19 for electrical and thermal energy use curves.

As shown in Figure 80, during the early and late night hours of the day when there was low electric load and high thermal demand, the GWP emissions from the processes were lower than that during the working hours of the day, when the electric load increased and the thermal energy use decreased. This might be because of the higher thermal efficiency of the boiler (90%) as compared to the thermal ratio of the other cogeneration processes. For example, at hour 6, when the 3-MW ICE required supplemental heat from the gas boiler, the GWP emission distribution from the 3-MW ICE cogeneration process was 91% CO_2, 8% CH_4, and 0.4% N_2O while at hour 14, when the cogeneration process met the thermal energy use of the building, 89% of the GWP emissions was CO_2, 10% CH_4, and 0.9% N_2O. At hour 6, about 65% of the CO_2 and N_2O emissions originated from the 3-MW ICE combustion process, 25% from the gas boiler, and the rest from upstream processes. Also, about 5% of the CH_4 emissions originated from the 3-MW ICE combustion process and the remaining from upstream gas processing systems. However, at hour 14, about 95% of the CO_2 and N_2O emission was from the 3-MW ICE combustion process and 15% of the CH_4 emissions were from the cogeneration combustion process and the rest from upstream gas processing operations.

Although the SOFC had higher electric efficiency than the 3-MW ICE, the emissions were relatively higher for the SOFC, mainly because of its lower thermal efficiency. When both cogeneration processes required supplemental heat, gas boilers were used to meet the thermal energy use but because of the lower thermal efficiency of the SOFC compared to the 3-MW ICE; more supplemental heat was required. Hence, the GWP from the SOFC was higher than that from the 3-MW ICE. For example, at hour 10, when both the cogeneration processes required some external heat input to meet the thermal load, with the SOFC, 68% of CO_2 emissions originated from the gas reforming and 27% from natural gas boiler while with the 3-MW ICE, 83% of CO_2 emissions was from the cogeneration combustion process and 16% from the gas boiler.

The main GWP emissions from the microturbine cogeneration process were CO_2, which mainly originated from the cogeneration combustion process. During the hours when the microturbine required supplemental heat to meet the thermal energy use of the building, such as early and late hours of the day (refer to Figure 19), a higher percentage of the CO_2 originated from the gas boiler. For instance, at hour 8 (when supplemental heat was required), the GWP emission distribution from the microturbine was 92% CO_2, 8% CH_4, and 0.09% N_2O (35% of the N_2O emissions was from the gas boiler while the rest from gas turbine). At that hour, 72% of the CO_2 emissions originated from the microturbine combustion process and 24% of the CO_2 from the gas boiler. On the other hand, at hour 10 (when no supplemental heat was required), the GWP emission distribution from the microturbine was 92% CO_2, 7% CH_4, and 0.06% N_2O (mainly from coal and gas driven steam turbines); 92% of the CO_2 emissions originated from the cogeneration combustion process.

Although the NGCC had the highest electrical efficiency (49%) compared to other processes, it produced higher GWP emissions than the cogeneration processes. Most of the CO_2 and N_2O emissions were from the NGCC process, but depending on the heat demand of the building, a high percentage of the CO_2 emissions originated from the gas boiler. For example at hour 10, the GWP emission distribution from the NGCC was 91% CO_2; (50% of which was from the NGCC and 21% from the gas boiler), and 0.5% N_2O; (76% from the NGCC and 10% from the gas boiler).

Generally, although there was a marked difference in GWP emissions between processes during working hours, over the whole day, cogeneration processes emit approximately same quantities of GWP. For instance, during peak hours (hours 9-17), the 3-MW ICE was the lowest emitting process but when summing the GWP over the day, its GWP was approximately equal to the GWP of the 143-kW ICE, mainly because during the non-working hours in the day (morning and night), the electric energy use was low, and most of the thermal load was met by the gas boiler for both processes.

May & August

In May and August, the GWP emission profile followed the electric energy use curve, as all the cogeneration processes produced more thermal energy than required. Generally, as shown in Figure 81 and 82, when the electric and thermal energy use were low, as in the early and late hours of the day, there was no significant difference in GWP whether the cogeneration processes were using electric chiller only or a combination of electric and absorption chillers because the co-generated heat from the cogeneration processes was too low to be utilized effectively to run the absorption chillers. However, as the electric and thermal load increased during the working hours of the day, GWP emissions were reduced significantly when using a combination of electric and absorption chillers as opposed to an electric chiller only, because the co-generated heat was used for cooling.

Unlike in January, in May and August, emissions from all processes followed the same trend during peak hours (hours 8-17) as over the whole day; processes with high electrical efficiencies produced less GWP emissions than those with lower efficiencies: NGCC produced the least emissions followed by the SOFC, then the 3-MW ICE, the 143-kW ICE, the average electric generation power plant, and finally the microturbine.

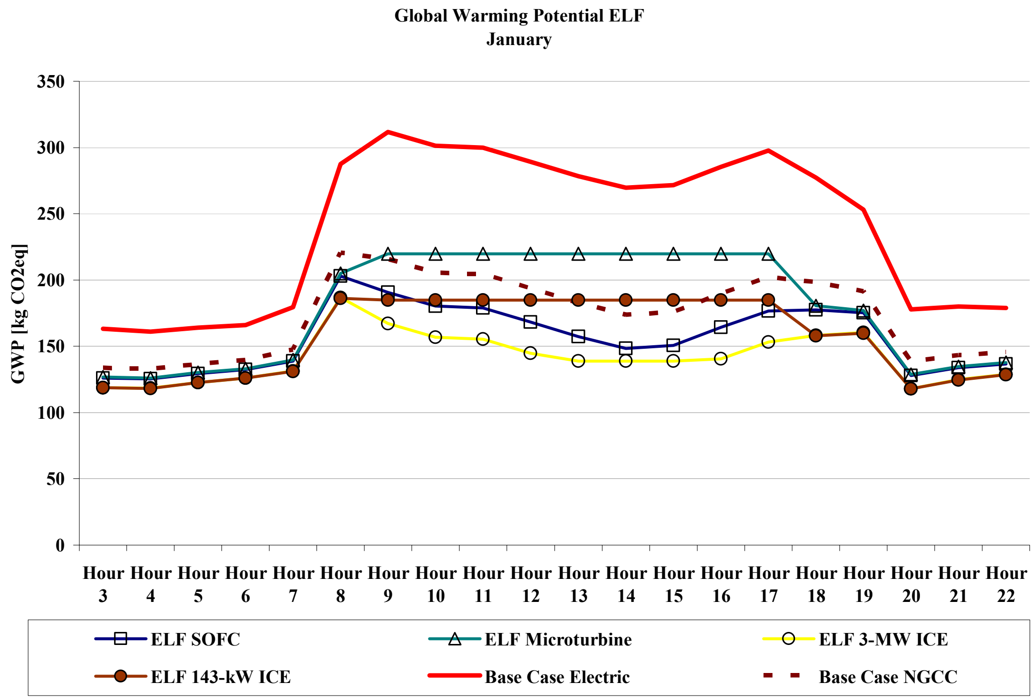

Figure 80: GWP during a Typical Day in January (ELF).

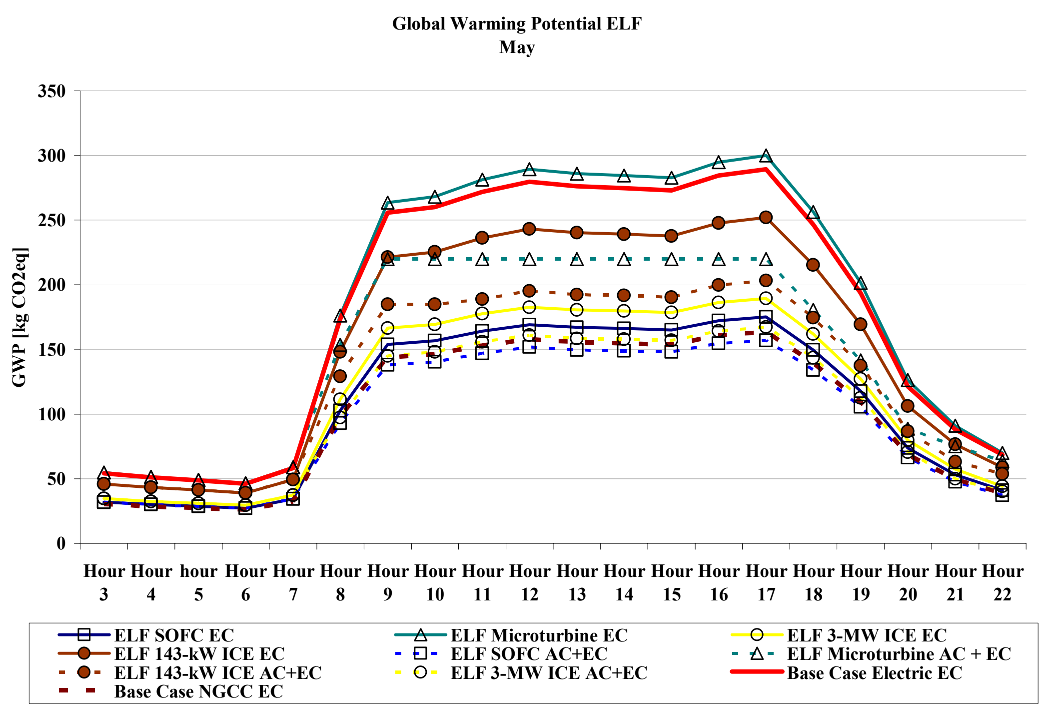

Figure 81: GWP during a Typical Day in May (ELF).

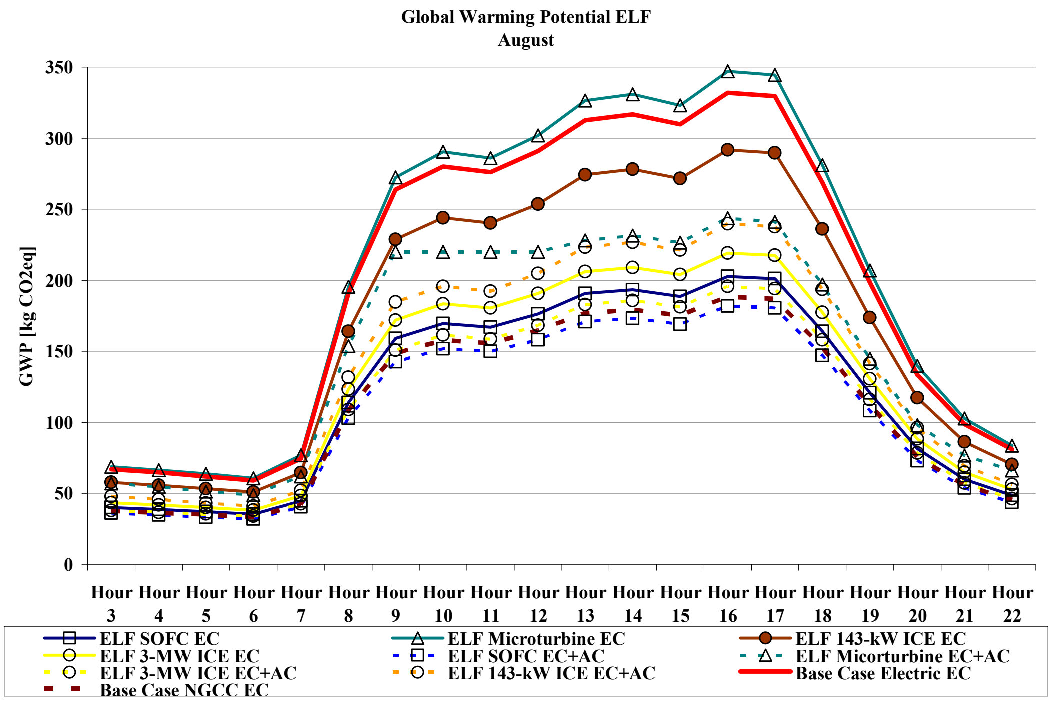

Figure 82: GWP during a Typical Day in August (ELF).

5.3 Tropospheric Ozone Precursor Potential (TOPP) (ELF)

5.3.1 Annual TOPP Analysis (ELF)

As shown in Figure 83, the average electric mix (EC) had the highest TOPP, followed by NGCC (EC), which had similar TOPP to the 143-kW ICE (EC), the 143-kW ICE (AC), the 3-MW ICE (EC), which had similar TOPP to the 3-MW ICE (AC), the microturbine (EC), the microturbine (AC), the SOFC (AC), and finally the SOFC (EC).

The TOPP emission distribution from the 3-MW ICE (EC), as well as the 3-MW ICE (AC), was 36% CO (98% of which was from the cogeneration combustion process, and rest from other upstream processes), 3% CH_4, 57% NOx (80% of the NOx emissions originated from the cogeneration combustion process, 13% from the gas turbine compressor, and the rest from other upstream processes), and 4% NMVOC (85% from the cogeneration combustion process, 10% from gas pipelines, 3% from gas turbine compressor, and rest from other upstream processes). The TOPP emission distribution from 143–kW ICE (EC) was similar to the 3-MW ICE (EC). The TOPP emission distribution from the 143-kW ICE (AC) was virtually similar to the 143-kW ICE (EC), except that because the cooling load was met by AC run by the cogeneration processes, portion of the emissions originated from that process.

The TOPP emission distribution from the microturbine (EC), as well as the microturbine (AC), was 13% CO (86% from the cogeneration combustion process, 7% from the gas turbine compressor, and rest from other upstream processes), 7% CH_4, 78% NOx (60% from the cogeneration combustion process, 26% from gas turbine compressor, and rest from other upstream processes), and 2% NMVOC (64% from the gas pipelines, 22% from the gas turbine compressor, and rest from other upstream processes).

The TOPP emission distribution from the SOFC (EC) was 5% CO (42% from gas turbine compressor, 10% from the cogeneration combustion process, and rest from other upstream processes), 73% NOx (65% from the gas turbine compressor, 14% from coal driven steam turbine, and the rest from upstream processes), 16% CH_4, and 5% NMVOC (18% from gas turbine compressor, 52% from gas pipelines, 16% from cogeneration combustion processes, and the rest from other upstream processes). The TOPP emission distribution of the SOFC (AC) was

5% CO (the majority of the CO emissions were from gas turbine compressor, 6% from the cogeneration combustion process, and rest from other upstream processes), 80% NOx (mainly from the gas turbine compressor), 8% CH_4, and 7% NMVOC (50% from gas turbine compressor, 8% from cogeneration combustion processes, and the rest from gas pipelines and other upstream processes).

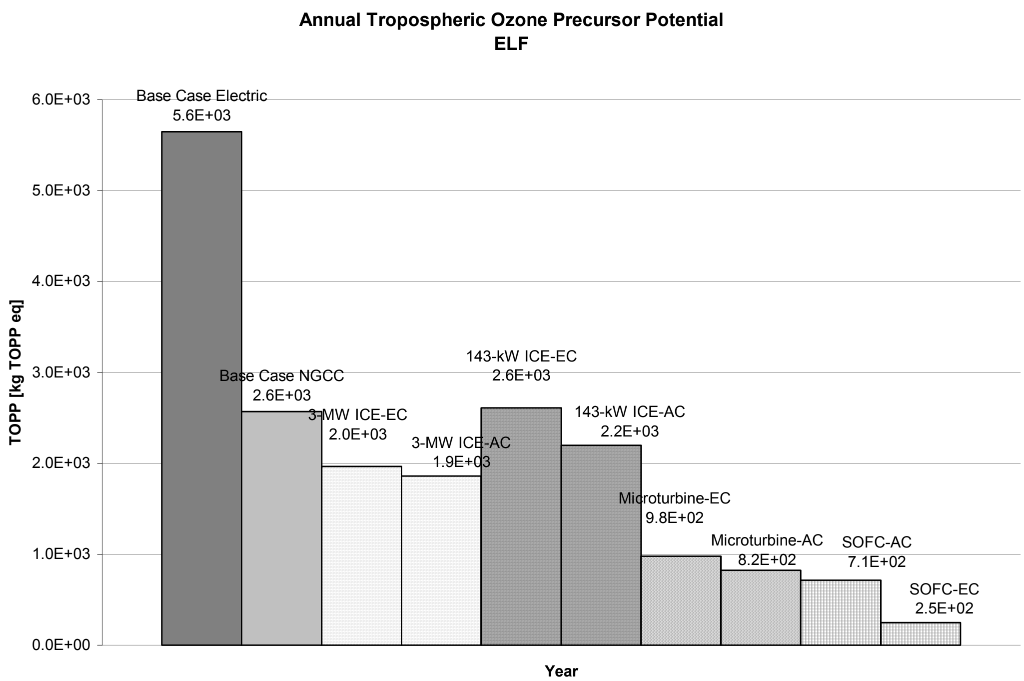

Figure 83: Annual TOPP (ELF).

5.3.2 Typical Day in a Month TOPP Analysis (ELF)

January

In a typical day in January, as shown in Figure 84, the SOFC and the microturbine produced the lowest TOPP emissions followed by the 3-MW ICE and the 143-kW ICE, the NGCC, and the average electric. The average electric produced eight times as much TOPP emission as the microturbine and the SOFC, about three times as much as from ICE units, and twice as much as that produced from the NGCC (EC).

In January, about 60% of TOPP from both the 3-MW and 143-kW ICE processes was NOx, (most of the NOx emissions originated from the cogeneration combustion process, although the 3-MW ICE process produced a higher percentage of NOx from the gas boiler than the 143-kW ICE because it required more supplemental heat); about 34 % of the TOPP emission was CO, also mainly from the cogeneration combustion processes, 5% was NMVOC (mainly from cogeneration combustion processes), and 3% was CH_4.

About 77% of the TOPP emission from the microturbine was NOx, (about 50% of which originated from the cogeneration combustion process, 26% from gas turbine compressor, 7% from the gas boiler, and the rest from upstream energy generation processes), 13% was CO, (about 80% of which originated from the cogeneration combustion process, 7% from the gas turbine compressor, 7% from the gas boiler, and the rest from upstream gas processing and energy generation operations), 3% NMVOC, (40% originates from gas processing, 38% from gas boiler, and 14% from gas turbine compressor while the rest from upstream processes), and 7% CH_4.

Although the microturbine and the 143-kW ICE required approximately the same quantity of supplemental heat to meet the thermal energy use of the building (both have similar thermal efficiencies), refer to Figure 28, the TOPP emissions from the 143-kW ICE was almost double that from the microturbine, as shown in Figure 84. Therefore, by using a microturbine instead of the 143-kW ICE for the generation of equal energy, the microturbine had the advantage of producing less TOPP and this could be attributed to the relatively lower content of CO emissions from the microturbine combustion process.

About 74% of the TOPP emission from the SOFC was NOx, 46% of which was from the cogeneration combustion process, 8% was CO, mainly from the gas boiler and gas processing, 9% was NMVOC, mostly from the gas boiler, and about 9% was CH_4.

In a typical day in January, the microturbine and the SOFC produced about 3 and 2 kg of TOPP equivalents, respectively; this was lower than the 143-kW ICE and the 3-MW ICE, which produce 7 and 6 kg of TOPP equivalents, respectively. The low emissions from the SOFC and microturbine could be due to the lower carbon monoxide percentage in the TOPP emission as compared to the 143-kW and 3-MW ICE processes. The TOPP emission from the SOFC was about 5% CO, the microturbine 14% while the 143-kW and 3-MW ICE was about 36% CO.

On the other hand, in January, the average electric generation power plant and NGCC had a low carbon monoxide (about 3%) percentage in their TOPP emission but much higher NOx (about 90%), and therefore, relatively higher overall TOPP compared to the cogeneration processes. The average electric produced about 16 kg of TOPP equivalents while the NGCC produced about 8 kg of the TOPP equivalents. The difference in TOPP between these two processes could be from the higher content of NMVOC in the TOPP emission from the average electric (average electric had about 8% NMVOC while the NGCC had about 3%).

The TOPP emission distribution from the NGCC was about 90% NOx, 4% CO, 3 % NMVOC, and 3% CH_4. About 73% of the NOx emissions originated from the NGCC, 13% from the gas boiler, 9% from the gas turbine compressor, and the rest of the NOx emissions originated from upstream energy generation processes. About 43% of the CO emissions originated from the gas boiler, 40% from the NGCC, 9% from the gas turbine compressor, and the rest from upstream gas processing and energy generation operations. About 67% of the NMVOC originated from the gas boiler, 14% from gas transportation processes, 10% from the NGCC, 5% from the gas turbine compressor, and the rest from upstream energy generation operations.

The TOPP emission distribution form the average electric was 88% NOx, 3% CO, 3% CO, 8% NMVOC, and 1% CH_4. About 53% of the NOx emissions originated from the coal driven steam turbine, 27% from the gas turbine, 7% from the gas boiler, 4% from waste driven steam turbine, 2% from the gas turbine compressor, and the rest from upstream energy generation processes. About 31% of the CO emissions originated from the gas boiler, 22% from coal driven steam turbine, 15% from gas turbine, 4% from waste driven steam turbine and rest from upstream energy generation processes. About 36% of the NMVOC emissions originated from the coal driven steam turbine, 26% from gas turbine, 15% from the gas boiler, 14% from waste driven steam turbine, and the rest of the emissions resulted from upstream fuels transportation and processing operation.

May & August

In May and August, as shown in Figure 85 and 86, the TOPP emissions from the cogeneration processes followed the same trend as in January: the SOFC produced fewer emissions than microturbine followed by the 3-MW ICE, and finally the 143-kw ICE. However, emissions from the 143-kw ICE, using electric chiller only, exceeded that from the NGCC in May and August whereas in January the 143-kW ICE performed better. When a combination of absorption and electric chillers were used, the 143-kW ICE had slightly less TOPP than the NGCC. The average electric had the highest TOPP when compared to the other processes.

In May and August, although the TOPP emission distribution from cogeneration processes appeared to be approximately equal to that in January, the origins of the emissions were different. For instance, in May, for the 143-kW ICE and 3-MW ICE, using EC only, the TOPP emission distribution was about 36% CO, 57% NOx, 4% NMVOC, and 3% CH_4, which was similar to January except for the NMVOC percentage, which was lower in May. However, in January, some of these emissions originated from the gas boiler while in May and August most of the emissions were from the cogeneration combustion process. In May, about 80% of the NOx emissions from the 143-kW ICE and 3-MW ICE originated from the cogeneration combustion processes and 13% from the gas turbine compressor. Also, 98% of the CO emissions originated from the cogeneration combustion processor, and 85% of the NMVOC emissions originated from the cogeneration combustion processes, the rest of the emissions originated from upstream energy generation processes.

In May, the TOPP emission distribution from the microturbine, using EC only, was 78% NOx, 13% CO, 2% NMVOC, and 7% CH_4. About 60% of the NOx emissions from the microturbine in May originated from the cogeneration combustion process and 26% from the gas turbine compressor while the rest of the NOx emissions originated from upstream energy generation processes. About 85% of the CO emissions originated from the cogeneration process, 7% from the gas turbine compressor, and the rest from upstream gas processing operations. About 64% of the NMVOC emissions originated from gas transportation processes, 22% from the gas turbine compressor, and the rest from upstream energy generation processes. Similar to January, in May and August, the microturbine had less TOPP than the 143-kW ICE although both had similar electrical efficiencies and co-generated same quantities of heat.

In May, the SOFC TOPP, using EC only, emission distribution was 73% NOx, 5% CO, 5% NMVOC, and 16% CH_4. About 65% of the NOx emissions originated from the gas turbine compressor and the rest of the NOx emissions originated from upstream energy generation processes. About 41% of the CO emissions originated from the gas turbine compressor, 9% from the SOFC, and the rest from upstream gas processing operations. Most of the NMVOC from the SOFC originated from natural gas reforming and transportation operations.

The TOPP emission distribution from the NGCC in May was 95% NOx, 3% CO, 1% NMVOC, and 2% CH_4. About 92% of the NOx emissions originated from the NGCC and 5% from the gas turbine compressor; 78% of the CO emissions originated from the NGCC and 9% from the gas turbine compressor, and 46% of the NMVOC from the NGCC and the rest of the emissions originated from upstream gas transportation and processing operations. Hence, unlike in January when some of the TOPP emissions originated from the gas boiler, in May and August because there was no need for supplemental heat from the gas boiler, most of the TOPP emissions originated from the NGCC process.

The TOPP emission distribution from the average electric was similar to January except that the TOPP in May and August originated mainly from the average electric generation mix processes while in January some of the emissions originated from the gas boiler. For instance, unlike in January when 31% of the CO emissions originated from the gas boiler, in May, the CO emissions originated mainly from the average electric generation mix processes: about 35% of the CO emissions originated from the coal driven steam turbine, 24% from the gas turbine, 6% from the waste driven steam turbine, and the rest from upstream energy generation processes.

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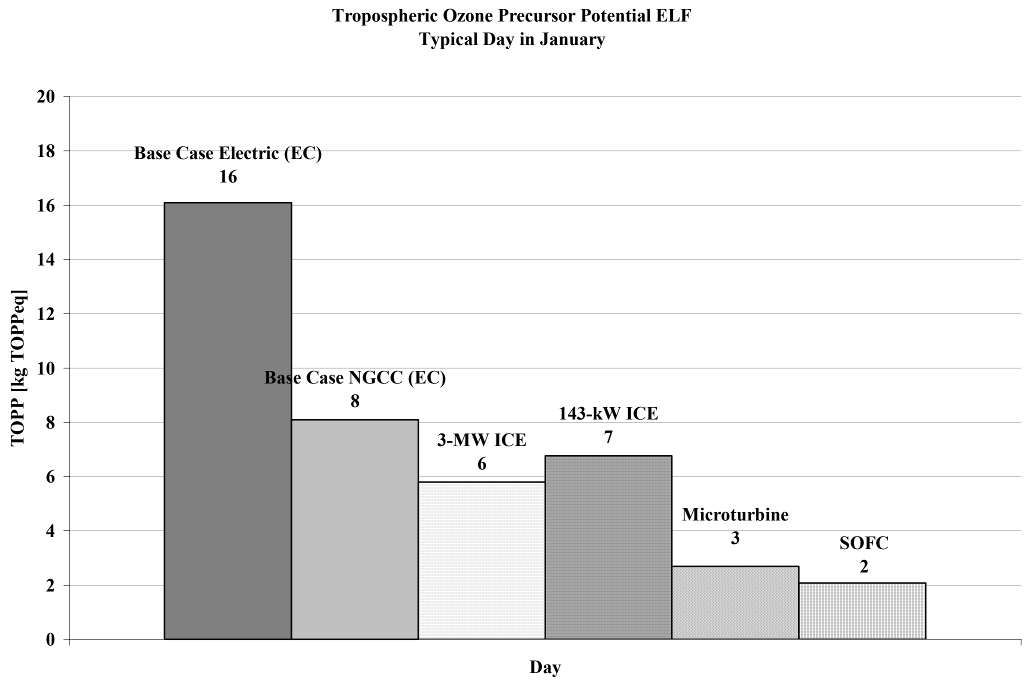

Figure 84: TOPP in a Typical Day in January (ELF).

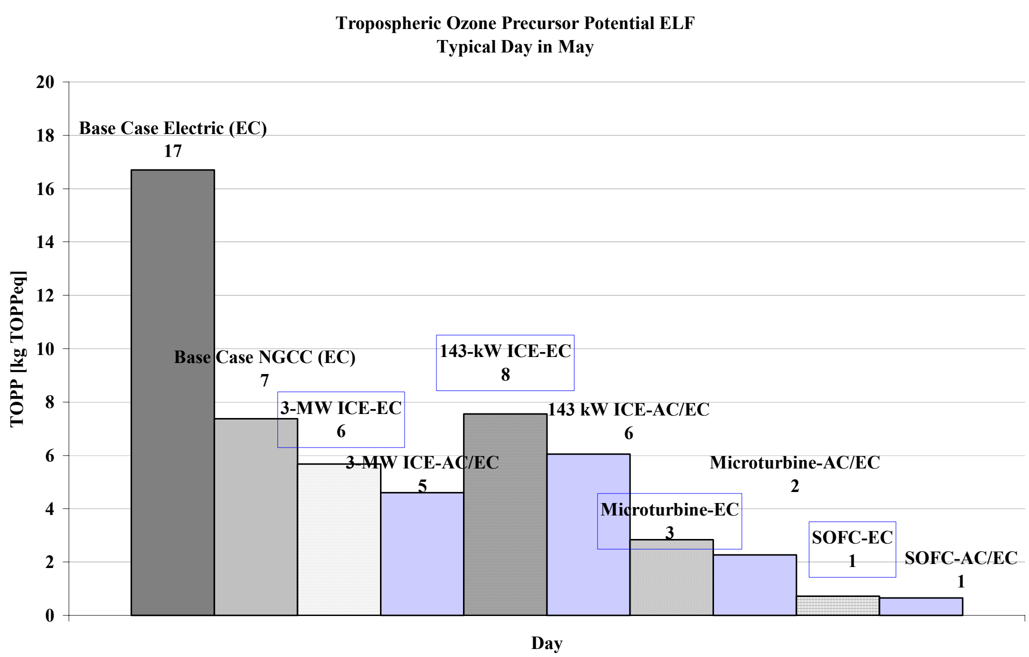

Figure 85: TOPP in a Typical Day in May (ELF).

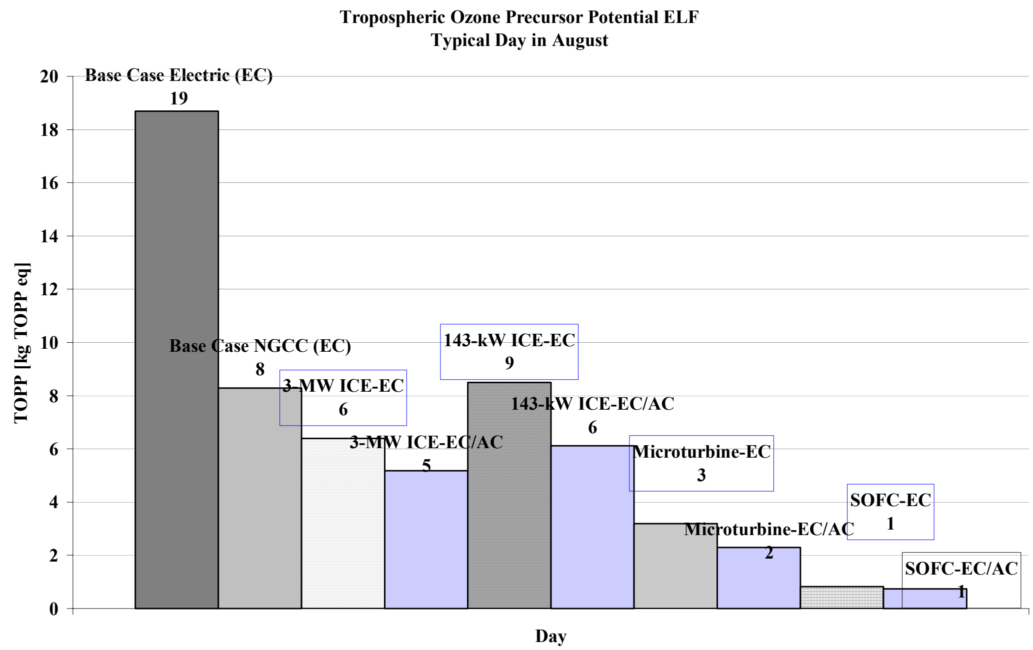

Figure 86: TOPP in a Typical Day in August (ELF).

5.3.3 Hourly TOPP Analysis (ELF)

January

Similar to the daily trend, as shown in Figure 87, the average electric mix had the highest TOPP, followed by the NGCC, the 143-kW ICE, the 3-MW ICE, the microturbine, and finally the SOFC. During the early and late hours of the day, all the cogeneration processes required supplemental heat to meet the thermal energy use of the building. Although both the microturbine and the 143-kW ICE had approximately equal electrical and thermal efficiencies ratio, the microturbine had less TOPP than the 143-kW ICE because the 143-kW ICE produced higher CO and NMVOC from the cogeneration combustion process than the microturbine.

The TOPP emission distribution from the 143-kW ICE at hour 8 was 60% NOx, (66% of the NOx emissions originated from the cogeneration combustion process, 14% from the gas turbine compressor, 12% from the gas boiler, and the rest from other upstream processes), 32% CO, (94% originated from the gas combustion process, 3% from the gas boiler, and 1% from the gas turbine compressor), 5% NMVOC, (60% from the cogeneration combustion process, 25% from the gas boiler, 10% from the gas distribution process, and 3% from gas turbine compressor), and 3% CH_4. During the working hours, when the electric load increased and the thermal load decreased, more of the TOPP emissions originated from the cogeneration combustion process. For example, at hour 14, 57% of the TOPP emission from the 143-kW ICE was NOx, (81% originated from the cogeneration combustion process and 13% from the gas turbine compressor), 36% was CO, (98% from the cogeneration combustion process and 1% from the compressor), 4% was NMVOC, (85% from the cogeneration combustion process, 10% from gas distribution process, and 3% from the compressor), and 3% was CH_4.

The TOPP emission distribution from the 3-MW ICE was similar to the 143-kW ICE except that because the 143-kW ICE had relatively higher thermal efficiency ratio than the 3–MW ICE, (the 143-kW ICE did not require supplemental heat from the gas boiler during the working hours of the day), the 143-kW ICE produced less percentage of the TOPP emissions from the gas boiler than with the 3-MW ICE. For instance, at hour 8, the TOPP emission distribution from the 3-MW ICE was 62% NOx, (55% of the NOx originated from the cogeneration combustion process, whereas, 20% from the gas boiler-versus 12% with the 143-

kW ICE), 29% CO, (90% originated from the cogeneration combustion process and 7% from the gas boiler), 6% NMVOC, (45% from the cogeneration combustion process, 40% from the gas boiler versus 25% with the 3-MW ICE, 10% from the gas distribution, and 3% from the gas compressor), and 4% CH_4. When the 3-MW ICE did not require supplemental heat, most of the TOPP emissions originated from the cogeneration combustion process. For instance, at hour 14 (no supplemental heat was required), the TOPP emission distribution from the 3-MW ICE was 57% NOx, (80% of the NOx originated from the cogeneration combustion process and 12% from the gas turbine compressor), 36% CO, (98% originated from the cogeneration combustion process), 4% NMVOC, (85% from the cogeneration combustion process, 10% from natural gas distribution, and 3% from the compressor) and 3% CH_4.

Although the microturbine did not require supplemental heat during the working hours of the day, its TOPP was relatively low when compared to the other processes, and comparable to the SOFC. During the early hours of the day, when the electrical load was low and thermal load was high, higher percentage of TOPP emissions from the microturbine originated from the gas boiler as compared to the working hours of the day, when the electrical load increased an the thermal load decreases. For instance, at hour 8, the TOPP emission distribution from the microturbine was 77% NOx, (43% of the NOx emissions originated form the cogeneration combustion process, 25% from the gas turbine compressor, 18% from gas boiler, and rest from upstream energy generation processes), 12% CO, (86% from the cogeneration combustion process, 17% from gas boiler, 7% from gas turbine compressor, and rest from other upstream processes), 4% NMVOC, (60% from the gas boiler, 26% from gas transportation processes, 8% from gas turbine compressor, and the rest from other upstream processes), and 7% CH_4. On the other hand, at hour 14, the TOPP emission distribution from the microturbine was 78% NOx, (60% of the NOx emissions originated from the cogeneration combustion process, 26% from gas turbine compressor, and the rest from other upstream processes), 13% CO, (86% from the cogeneration combustion process, 7% from gas turbine compressor, and the rest from upstream processes), 2% NMVOC, (64% of the NMVOC originated from the gas transportation processes, 22% from the gas compressor, and the rest from other upstream processes), and 7% CH_4.

During early and late hours of the day when the electrical load was low and the thermal load was high, the SOFC produced more TOPP emissions than during the working hours of the day when the electrical load increased. This was because the SOFC had a high electrical efficiency. When the electric load was high, as during the working hours, it utilized more of its co-generated heat and required less supplemental heat from the gas boiler to meet the thermal energy use of the building. For instance, at hour 8 (low electrical load), the TOPP emission distribution from the SOFC was 74% NOx, (50% from the gas boiler and 32% from the gas turbine compressor) 8% CO, (80% from the gas boiler and 13% from the compressor), 10% NMVOC, (74% from the gas boiler), and 8% CH_4. On the other hand, at hour 14 (higher electrical load), the TOPP emission distribution from the SOFC was 73% NOx, (52% originated from the compressor and 20% from the gas boiler), 6% CO, (35% from the gas boiler and 28% from the compressor), 7% NMVOC, (42% from the gas boiler, 32% from gas distribution, 11% from compressor, and 9% from SOFC combustion process), and 13% CH_4.

May & August

As shown in Figure 88 and Figure 89, in May and August, with the electric chiller alone, the SOFC and the microturbine continued to have the lowest TOPP emissions, followed by the 3-MW ICE. The 143-kW ICE (EC) appeared to have the same TOPP as the NGCC, and finally the average electric had the highest TOPP. However, using a combination of electric and absorption chillers lowered the TOPP from all cogeneration processes during working hours, making all the cogeneration processes attractive alternatives to the NGCC and the average electric.

In May, all the cogeneration processes were able to utilize their co-generated heat and meet the thermal load of the building during early and late hours of the day. Also, all the cogeneration processes, except the SOFC, co-generated more heat than required during the working hours of the day, when the electric and the cooling loads increased. During the working hours, the SOFC required supplemental energy to meet the cooling load with AC; nevertheless, the SOFC had the lowest TOPP.

August was similar to May except that the magnitude of TOPP emission increased with the increase in electric and cooling loads.

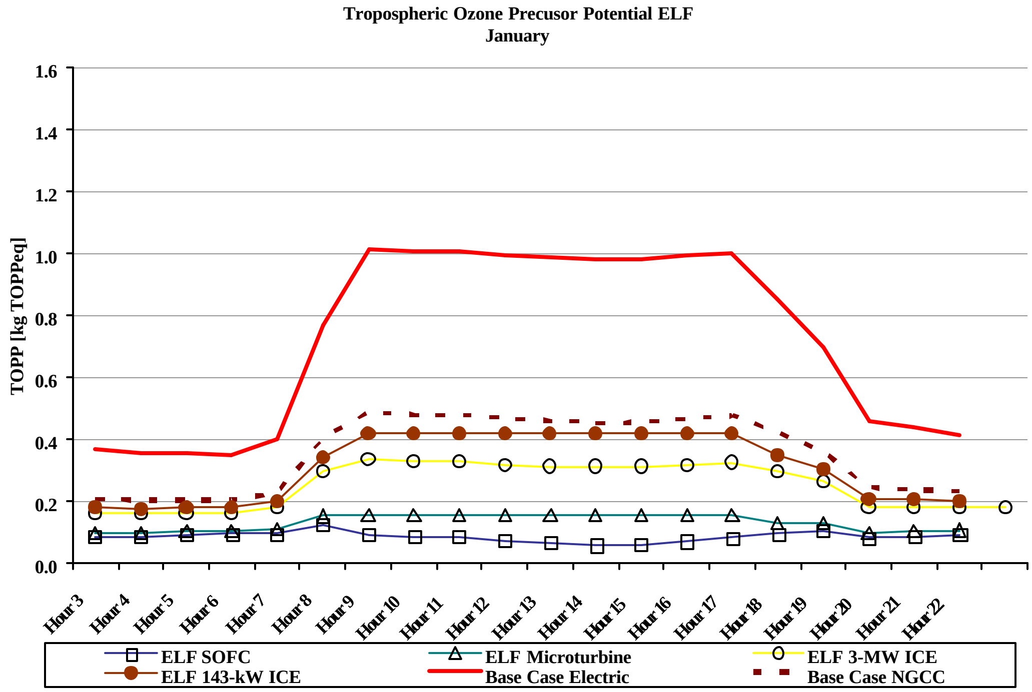

Figure 87: TOPP during a Typical Day in January (ELF).

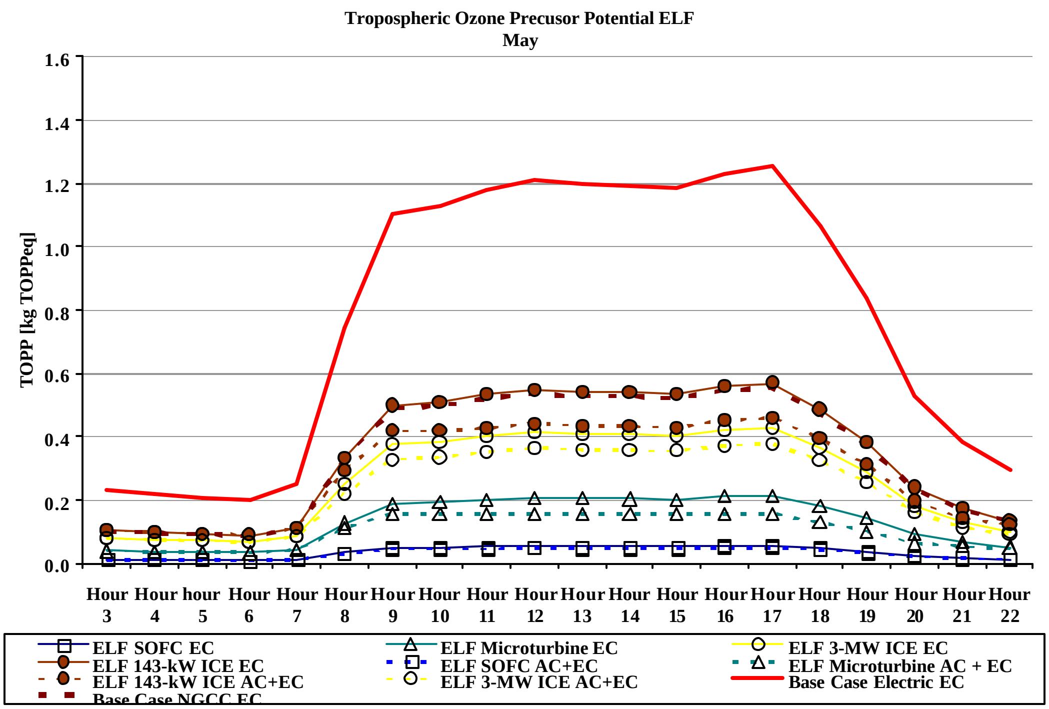

Figure 88: TOPP during a Typical Day in May (ELF).

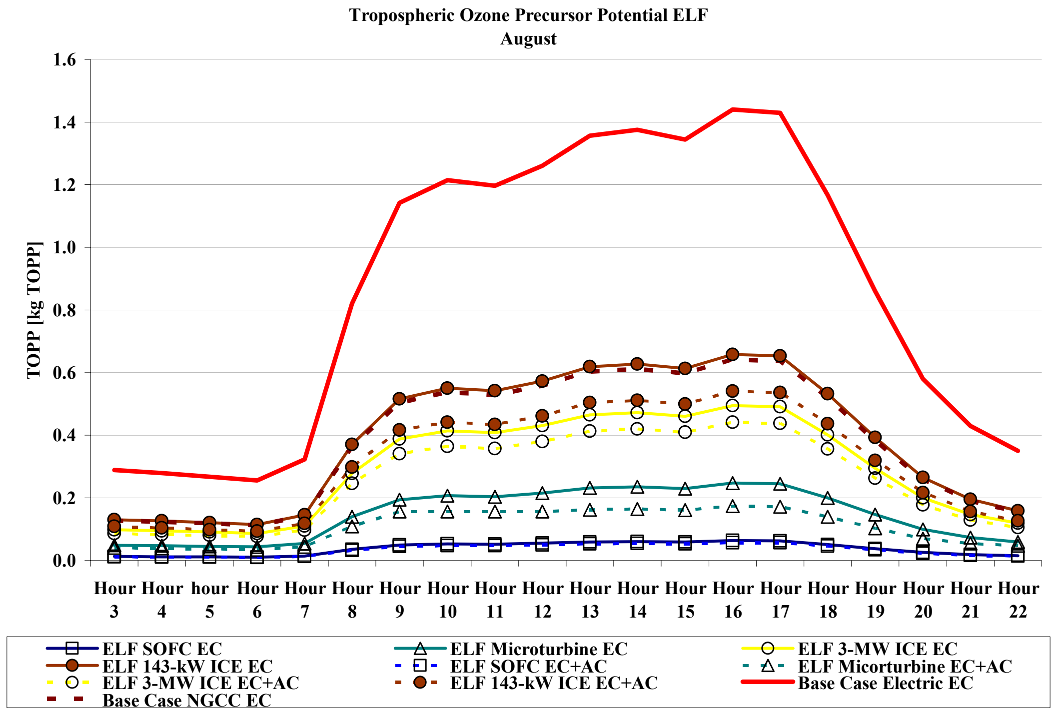

Figure 89: TOPP during a Typical Day in August (ELF).

5.4 Acidification Potential Analysis (AP) (ELF)

5.4.1 Annual AP Analysis (ELF)

The AP emission profile, shown in Figure 90, resembles the TOPP (ELF) profile. The average electric mix had the highest AP, followed by the 143-kW ICE (EC), which had similar AP to the NGCC (EC), the 143-kW ICE (AC), the 3-MW ICE (EC), which was approximately equal to the 3-MW ICE (AC), the microturbine (EC), the microturbine (AC), the SOFC (AC), and finally the SOFC (AC). All the cogeneration process, except the SOFC, using the EC to meet the cooling load, had higher AP than when using AC. This was mainly because their thermal ratio was higher than their electrical efficiency, whereas, the SOFC had higher electrical efficiency ratio.

The AP emission distribution from the 3-MW ICE (EC), as well as the 3-MW ICE (AC) was 90% NOx[14] and 10% SO_2 (5% of the SO_2 emissions were from the cogeneration combustion process, 60% from coal driven steam turbine, 19% from oil driven steam turbine, and the rest from other upstream processes). The AP emission distribution from 143–kW ICE was similar to the 3-MW ICE.

The AP emission distribution from the microturbine (EC), as well as the microturbine (AC), was 80% NOx and 19% SO_2 (58% from coal driven steam turbine, 9% from oil driven steam turbine, about 9% from the cogeneration combustion process, and the rest from other upstream processes).

The AP emission distribution of the SOFC (EC) was 63% NOx and 35% SO_2 (62% from coal driven steam turbine, 19% from oil driven steam turbine, and the rest from other upstream processes). The AP emission distribution of the SOFC (AC) was 81% NOx and 18% SO_2 (42% from coal driven steam turbine, and the rest mainly from oil related processes and other upstream processes).

[14]Refer to the section of annual TOPP (ELF) analysis for origins of NOx emissions.

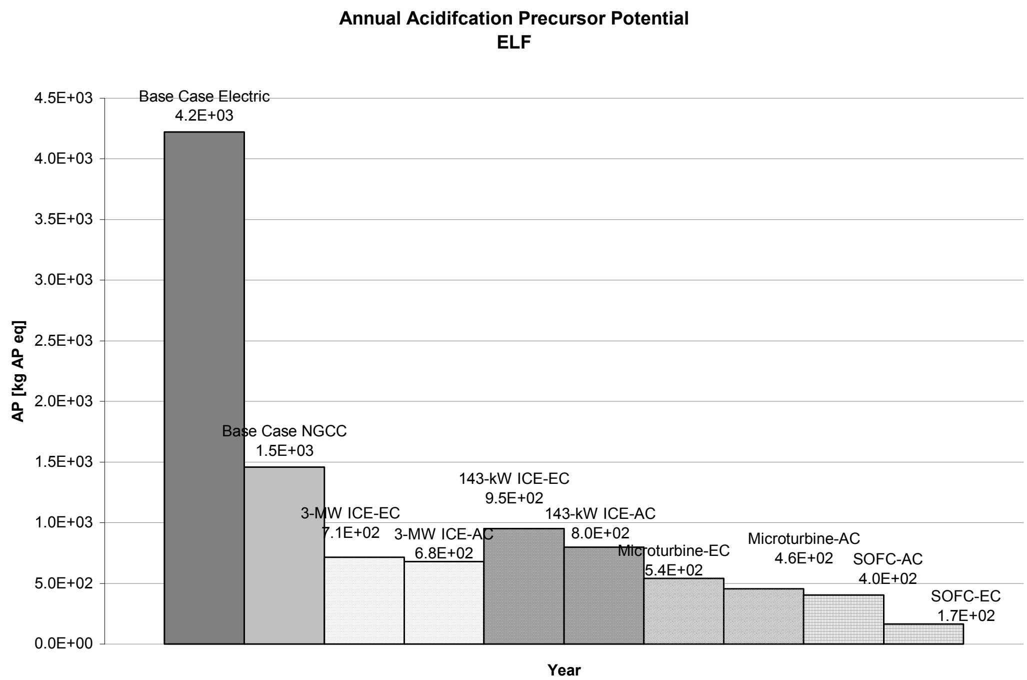

Figure 90: Annual AP (ELF).

5.4.2 Typical Day in a Month AP Analysis (ELF)

January

Similar to TOPP, as shown in Figure 91, the average electric produced the highest AP, followed by the NGCC, the 143-kW ICE, the 3-MW ICE, and finally the SOFC which produced the lowest emissions. However, the difference between the AP magnitude from the average electric and the other cogeneration processes was even greater than the difference in TOPP. This was primarily because natural gas has much lower sulfur content than coal, the primary generation fuel in the cogeneration processes and the NGCC. The average electric had twice as much AP as the NGCC.

The AP emission distribution from the average electric was 69% NOx, (53% of the NOx emission originated from coal driven steam turbines, 27% from gas turbine, and 7% from gas boiler), and 29% SO_2, (most of which originated from electric generation mix processes-76% of the SO_2 coal driven steam turbine etc.). On the other hand, the AP emission distribution from the NGCC was 92% NOx, (74% of the NOx emissions originated from the NGCC, 13% from the gas boiler, 9% from gas compressor, and the rest from upstream electric generation processes), and only 7% SO_2, (most of which originated from upstream electric generation processes; about 56% from coal driven steam turbine, 17 from oil driven steam turbines, and 12% from the NGCC).

Since the SOFC co-generated low thermal energy while following the electric load (because of its low thermal efficiency ratio), it required supplemental heat to meet the thermal energy use of the building. Most of the AP emissions from the SOFC originated from the gas boiler and upstream electric generation processes. The AP emission distribution from the SOFC was 76% NOx, (46% from the gas boiler, 35% from gas turbine compressor, and the rest from upstream electric generation processes) and 23% SO_2, (62% from coal driven steam turbine, and 19% from oil driven steam turbine).

The AP emission distribution from the 143-kW ICE was 89% NOx, (74% of the NOx emissions originated from the cogeneration combustion process, 14% from the gas turbine compressor, and 5% from the gas boiler), and 11% was SO_2, (61% from coal driven steam turbine, 19% from oil driven steam turbine, and 4% from the cogeneration combustion process).

The AP emission distribution from the 3-MW ICE was 87% NOx, (62% of the NOx emissions originated from the cogeneration combustion process, 15% form the gas turbine compressor, and 14% from the gas boiler), and 12% SO_2, (60% from coal driven steam turbine, 18% form oil driven steam turbine, and 8% from the cogeneration combustion process). With the 3-MW ICE more AP emissions originated from the gas boiler than with the 143-kW ICE because the 3-MW ICE co-generated less heat than the 143-kW because of its lower thermal efficiency and hence required more supplemental heat (from the gas boiler) to meet the thermal energy use of the building. Although the sources of AP emissions from the 143-kW and 3-MW ICE were different, their AP was approximately equal: the 143-kW ICE produced 3 kg of SO_2 equivalence and the 3-MW ICE produces 2 kg of SO_2 equivalence.

The AP emission distribution from the microturbine was 80% NOx, (53% of the NOx emissions originated from the cogeneration process, 35% from the gas turbine compressor, and 7% from the gas boiler), and 19% SO_2, (60% from coal driven steam turbine, 18% from oil driven steam turbine, and 8% from the cogeneration combustion process).

Generally, all the cogeneration processes had approximately equal AP but much lower than the average electric mix.

May & August

As shown in Figure 92 and 93, the AP emission profile was similar in both months, May and August: the average electric had the highest AP, followed by the NGCC, the 143-kW ICE, the 3-MW ICE, the microturbine, and finally the SOFC. Generally, when the cogeneration processes used a combination of absorption and electric chillers instead of electric chillers only, the AP emissions were reduced, although not significantly. As explained earlier, the average electric had the highest AP because of the higher content of sulfur in its fuel as compared to natural gas, which was used by the NGCC and the cogeneration processes. For instance, in May, SO_2 percentage of AP for the NGCC was 5%, the 143-kW ICE and 3-MW ICE percentages were about 10% SO_2, the microturbine's percentage was about 20%, and the average electric generation power plant's percentage of AP was about 30% SO_2.

In May and August, because of the low thermal energy use of the building, all the cogeneration processes co-generated more heat than required, and hence, unlike in January when some of the AP emissions originated from the gas boiler, in these months, most of the AP emissions were either from the cogeneration combustion processes or from upstream energy generation processes.

In May, the AP emission distribution from the average electric and the sources of emissions were similar to January: 68% NOx and 30% SO_2. However, the AP emission distribution from the NGCC in May differs from January as less heat was required: 94% NOx, (92% of the NOx emissions originated from the NGCC and 5% from the gas turbine compressor), and 5% SO_2, (49% from coal driven steam turbine, 23% from the NGCC, and 15% from the oil driven steam turbine).

With no supplemental heat required, most of the AP emissions from the SOFC originated from upstream processes, unlike in January where some of the NOx emissions originated from the gas boiler. The AP emission distribution from the SOFC was 63% NOx, (65% from gas turbine compressor, 13% from coal driven steam turbine, and the rest from upstream energy generation processes), and 35% SO_2, (origins of emissions were similar to January).

In May and August, both the 143-kW ICE and the 3-MW ICE processes had similar AP emission distribution and similar sources of emissions. However, unlike January, most of the NOx emissions were generated from the cogeneration combustion processes. The AP emission distribution from the ICE was: 89% NOx, (80% from the cogeneration combustion processes, 12% from gas turbine compressor, and the rest from upstream energy generation processes), and 10% SO_2, (sources of emissions were similar to January).

The AP emission distribution, as well as the sources of emissions, from the microturbine was similar to January: 80% NOx and 19% SO_2.

When the cogeneration processes used a combination of absorption and electric chillers, they utilized the co-generated heat in running the absorption chillers, and therefore, did not produce additional emissions; instead, they reduced the emissions by eliminating the use of electric chillers in some cases where the co-generated heat was sufficient to run the absorption chillers for cooling.

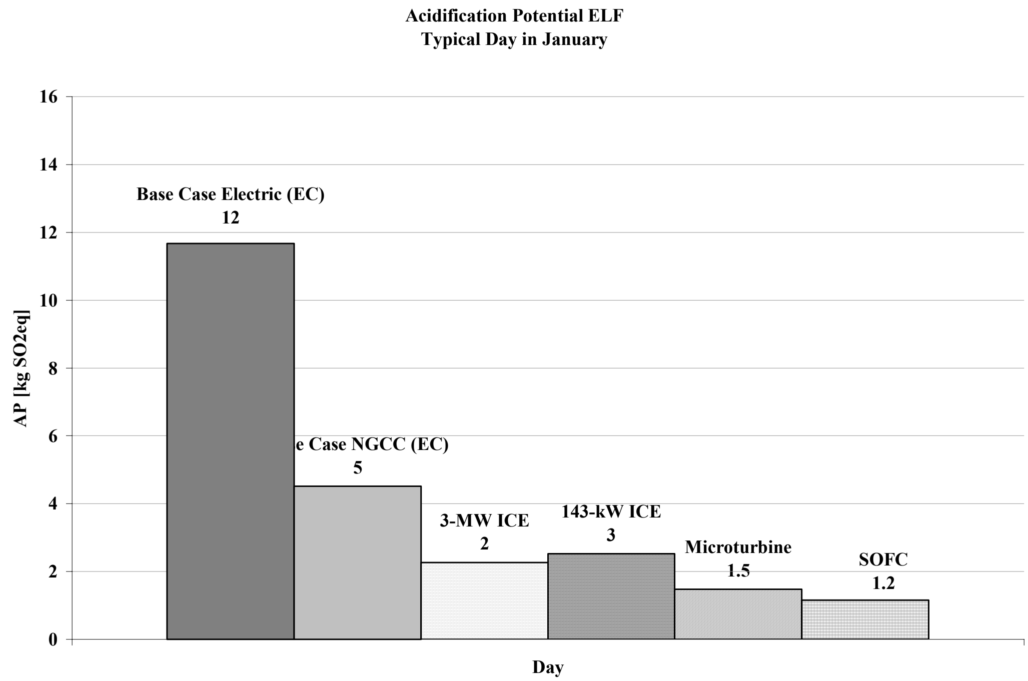

Figure 91: AP in a Typical Day in January (ELF).

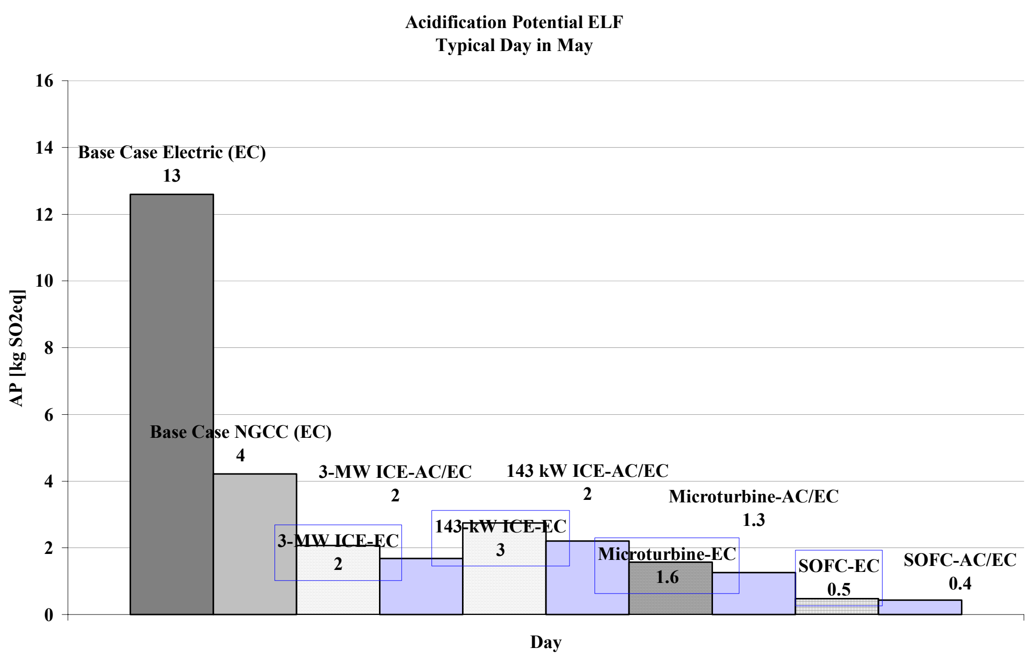

Figure 92: AP in a Typical Day in May (ELF).

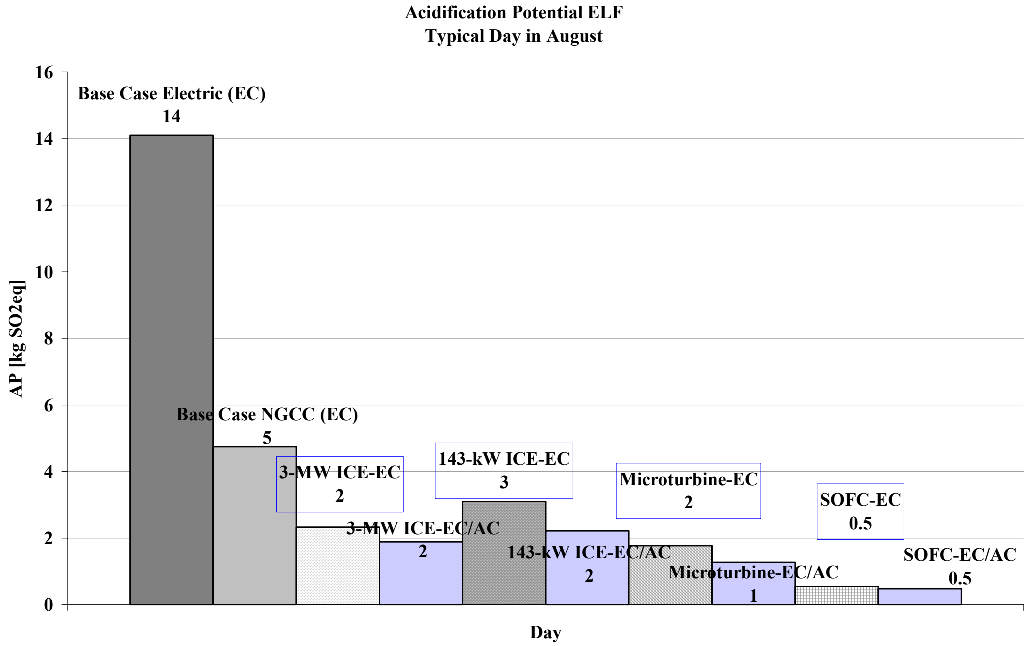

Figure 93: AP in a Typical Day in August (ELF).

5.4.3 Hourly AP Analysis (ELF)

January

The AP profile of the processes was similar to the TOPP in January but the magnitudes of AP emissions were less than the TOPP. As shown in Figure 94, the AP emissions were the average electric mix had the highest AP, followed by the NGCC, the 143-kW ICE, the 3-MW ICE, the microturbine, and finally the SOFC.

The AP emission distribution from the 143-kW ICE was about 90% NOx and 10% SO_2. During the early and late hours of the day, when the 143-kW ICE required supplemental heat, some of the NOx emission originated from the gas boiler, whereas, during the working hours of the day when the cogeneration process did not require supplemental heat, more of the NOx emission originated from the cogeneration combustion process (as described in the TOPP section). Most of the SO_2 emission originated from upstream processes: about 60% of the SO_2 emission originated from the coal driven steam turbine and 19% from oil driven steam turbine, whereas, only about 5% originated from the cogeneration combustion process. The AP emission distribution from the 3-MW ICE was similar to the 143-kW ICE (the NOx emission sources were the same as in the TOPP).

The AP emission distribution from the microturbine was about 80% NOx and 19% SO_2. The NOx emission sources were the same as that of the TOPP. Most of the SO_2 emission originated from upstream processes: 60% from coal driven steam turbine, 18% from oil driven steam turbine, and only about 8% from the cogeneration combustion process.

The AP emission distribution form the SOFC was about 70% NOx and 20-30% SO_2. The NOx emission sources were the same as that of the TOPP. SO_2 emission originated from upstream processes, such as coal and oil driven steam turbines and fuel transportation. As the electrical load increased and the SOFC utilized more of its co-generated heat to meet the thermal load, and hence used less heat from the gas boiler, the SO_2 percentage in the AP emissions decreased. For instance, at hour 8 (low electric load and high thermal load), the SO_2 was about 22% while at hour 14 (higher electric load and lower thermal load), the SO_2 was about 30%.

May and August

As shown in Figure 95 and Figure 96, the AP profile of the processes resembles the TOPP profile in May and August. Generally, the SOFC and the microturbine had the lowest AP, followed by the 3-MW ICE, the 143-kW ICE, the NGCC, and finally the average electric mix has the highest TOPP. Using a combination of electric and absorption chillers lowered the AP from all cogeneration processes during working hours.

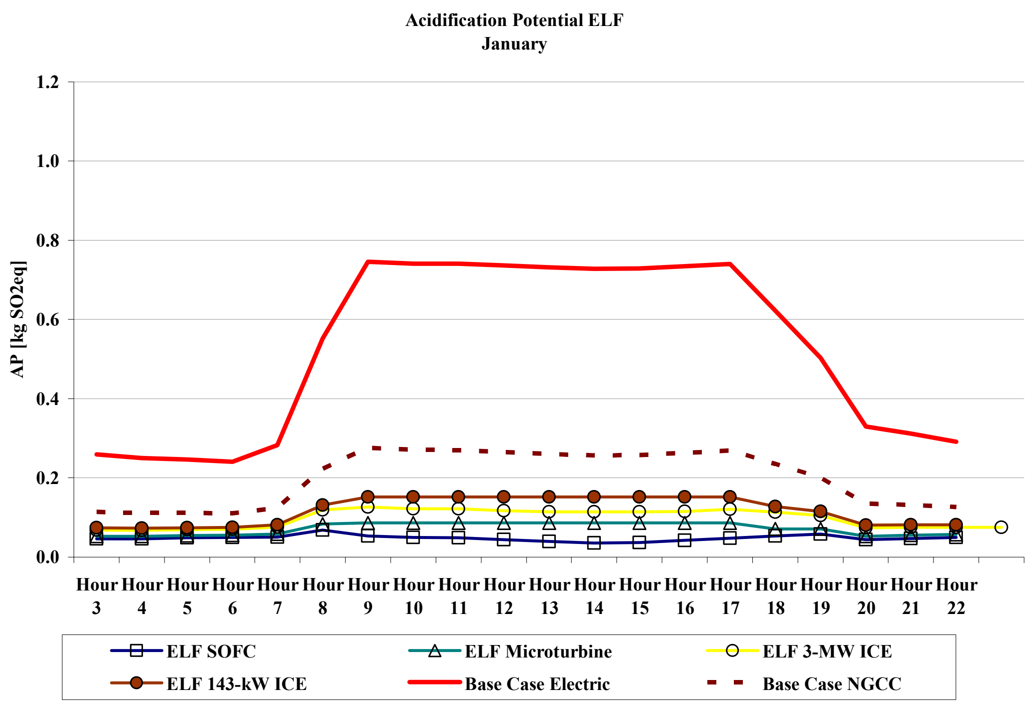

Figure 94: AP during a Typical Day in January (ELF).

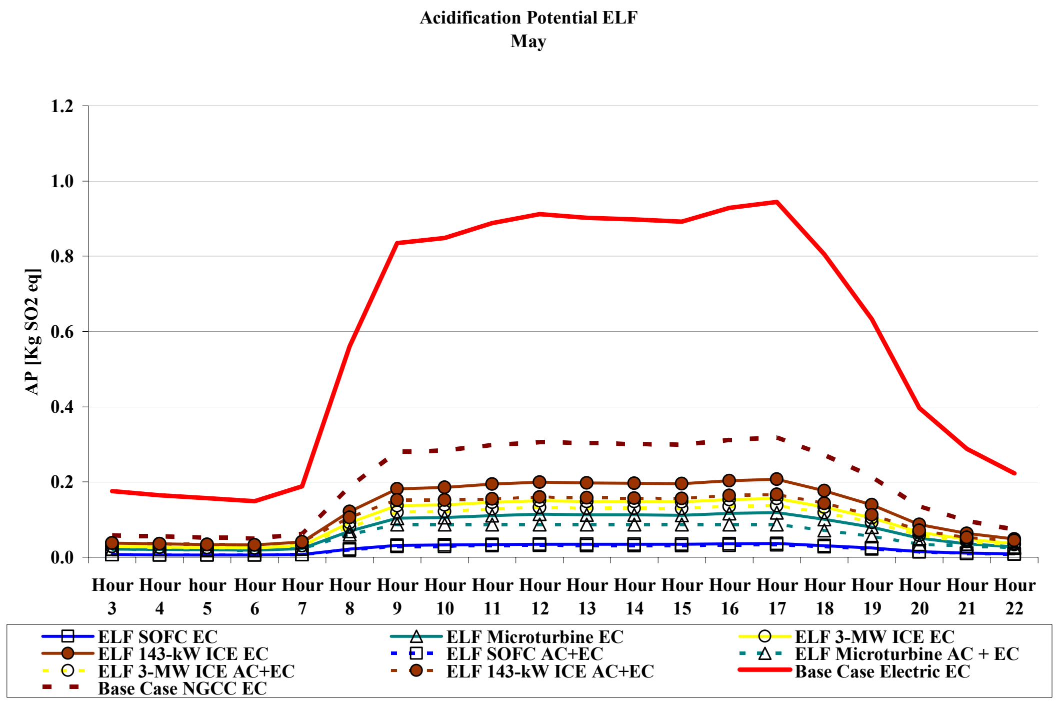

Figure 95: AP during a Typical Day in May (ELF).

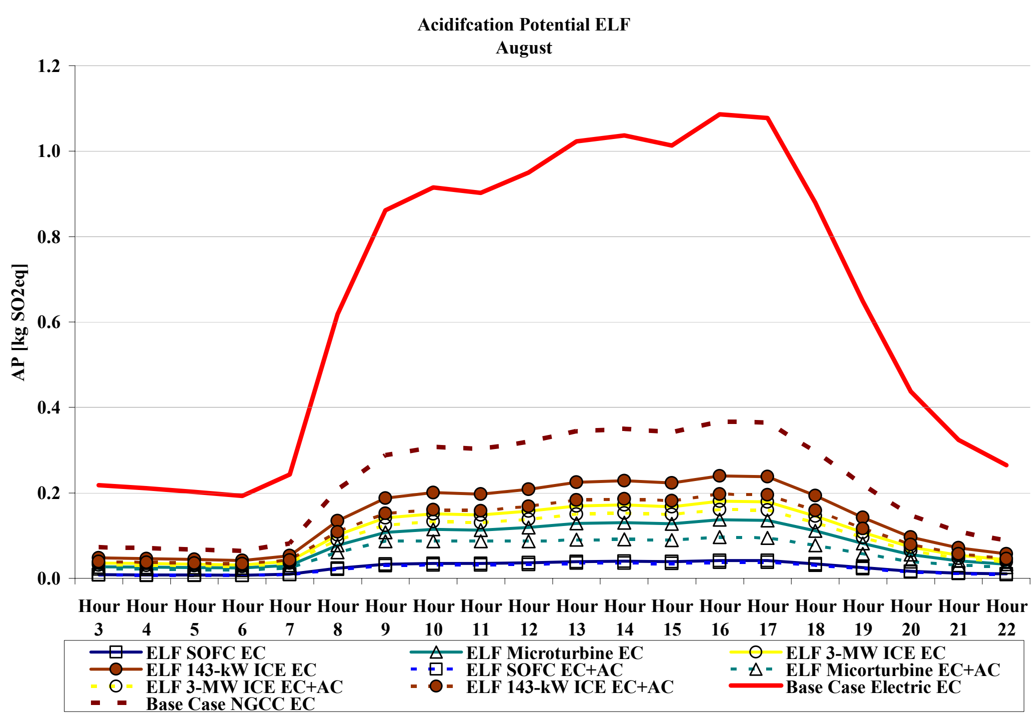

Figure 96: AP during a Typical Day in August (ELF).

5.5 Summary of Results (ELF)

5.5.1 Normalized Curves for Single Environmental Indicators in all Months (ELF)

Figures 97-100 show the normalized graphs used to compare the monthly primary energy consumption, GWP, TOPP, and AP in a typical day for the electrical load following (ELF) scenarios. For ELF scenarios in a typical day in a month, cogeneration processes were operated to meet the electrical load of the building.

As shown in Figure 97 and Figure 98, in January, the average electric mix (EC) had the highest primary energy consumption and GWP emissions followed by the NGCC (EC) while all the cogeneration processes had lower and approximately equal energy use and GWP emissions.

Generally, when a cogeneration process uses an electric chiller (EC) only to meet the cooling energy use of the building, it consumes relatively higher primary energy and produces relatively higher emissions than when using a combination of electric and absorption chillers, where the otherwise wasted co-generated heat is utilized in running the absorption chiller (AC) to meet part/all of the cooling load. For instance, In May, as shown in Figure 97, the microturbine using electric chiller (EC) to meet the cooling energy use of the building had the highest primary energy consumption followed by the 143-kW ICE and the average electric mix; however, when using both absorption and electric chillers, the energy consumption by the microturbine and the 143-kW ICE decreased significantly and became approximately equal to the average electric. Likewise, as shown in Figure 97 and 98, the 3-MW using EC only had higher primary energy consumption and GWP emissions than the NGCC but when both AC and EC were used, the energy consumption and GWP emissions from the 3-MW ICE became less than the NGCC.

On the other hand, using a combination of AC and EC did not result in a significant reduction in energy use and GWP emissions for the SOFC when compared to EC alone, mainly because the SOFC had low thermal efficiency, and hence, did not produce large quantities of thermal energy that could be utilized to run the absorption chiller. Nevertheless, the SOFC had a relatively low energy use and GWP emissions when compared to the other processes in May and August because of its high electrical efficiency.

In May and August, as shown in Figure 98, all the cogeneration processes had higher GWP than the NGCC when they used EC to meet the cooling load. When a combination of AC and EC were used, the GWP emissions from the cogeneration processes decreased significantly (except for the SOFC), the SOFC and 3-MW ICE using AC and EC had similar GWP to the NGCC while the other two cogeneration processes continued to have higher GWP than the NGCC but lower than the average electric mix.

Figure 99 shows the TOPP emissions from all processes. The average electric mix had the highest TOPP emissions in all months. In January, the NGCC had the second highest TOPP emissions followed by the 143-kW ICE, the 3–MW ICE, and the microturbine while the SOFC had the lowest TOPP. In May, the same sequence of TOPP emissions from the cogeneration processes occurred as in January when both AC and EC were used to meet the cooling energy use of the building; however, when EC was used the TOPP emission from the cogeneration processes increased and the 143-kW ICE had higher TOPP than the NGCC. The TOPP in August was similar to May.

As shown in Figure 100, similar to TOPP emissions profile, the average electric had the highest AP emissions in all months. In January, the NGCC had the second highest AP emissions followed by the 143-kW ICE, the 3-MW ICE, the microturbine and the SOFC. In May and August, the AP emissions profile was similar to January; however, using a combination of AC and EC in the cogeneration processes decreased the AP emissions than when using the EC only.

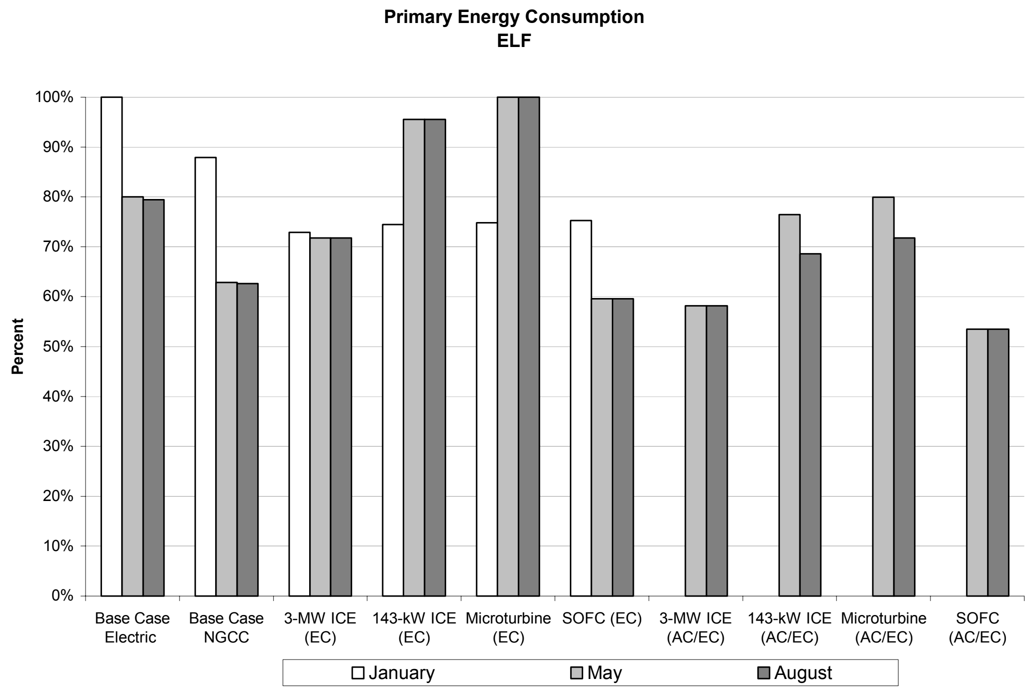

Figure 97: Normalized Energy Consumption for a Typical Day in Each Month (ELF).

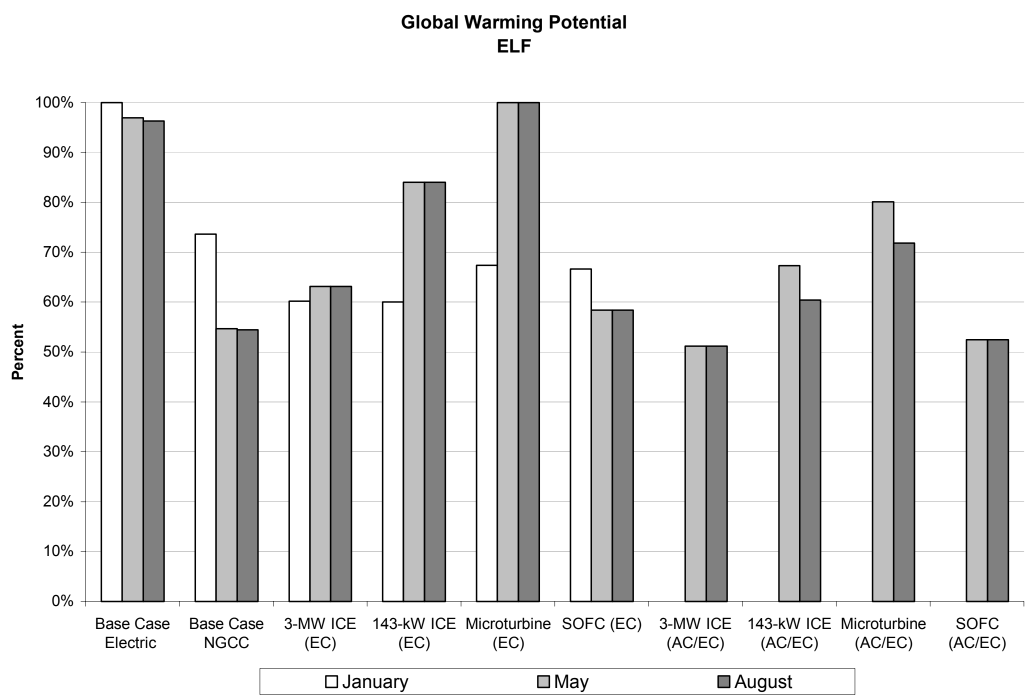

Figure 98: Normalized GWP for a Typical Day in Each Month (ELF).

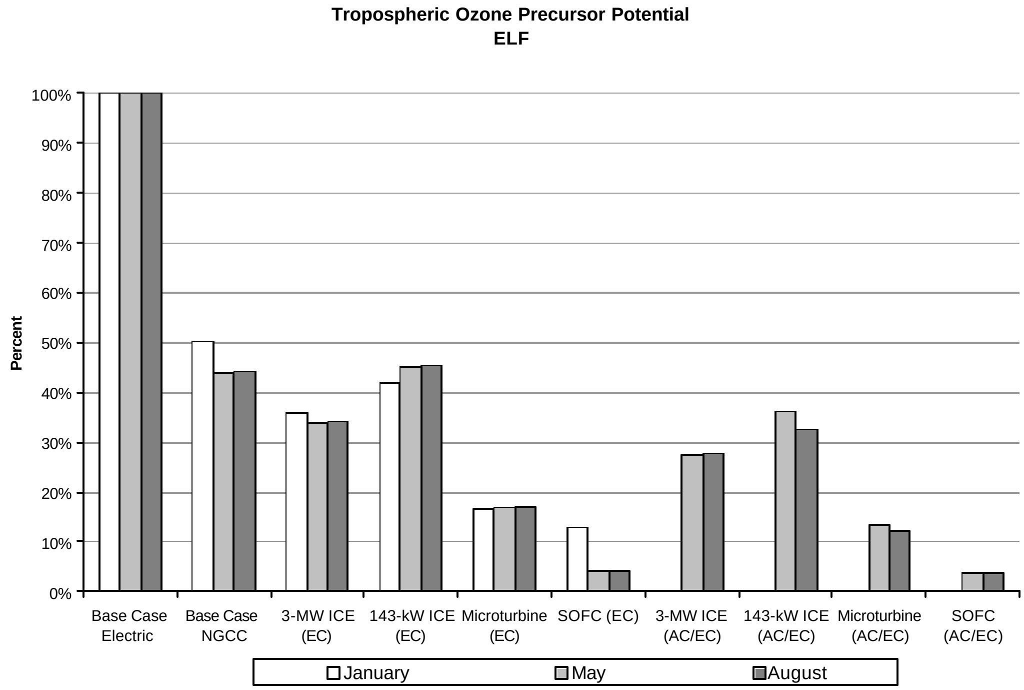

Figure 99: Normalized TOPP for a Typical Day in Each Month (ELF).

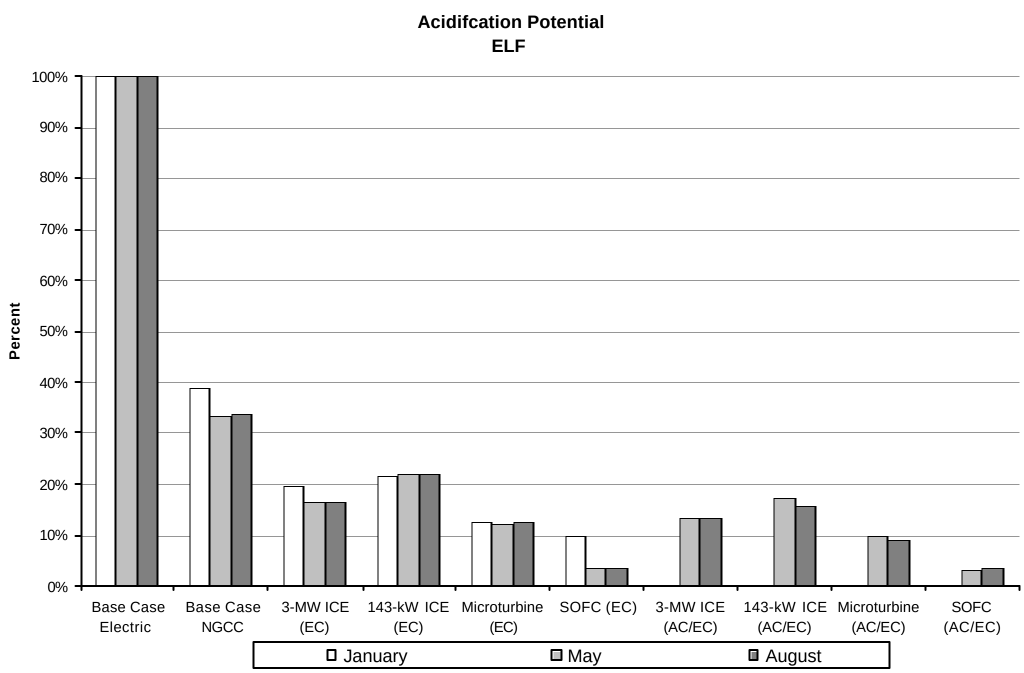

Figure 100: Normalized AP for a Typical Day in Each Month (ELF).

5.5.2 Normalized Curves for All Environmental Indicators in Each Month (ELF)

Figures 101-105 show the normalized graphs used to compare the primary energy consumption, GWP, TOPP, and AP emissions in a typical day in a month.

As shown in Figure 101, in a typical day in January, the average electric mix had the highest primary energy consumption, GWP, TOPP, and AP emissions. All the cogeneration processes had approximately equal energy consumption, which was slightly less than the NGCC.

When comparing the energy consumption and GWP emissions from the cogeneration processes, they all appeared to have similar energy consumption and GWP. The NGCC had slightly higher GWP emissions than the other cogeneration processes and the ICE cogeneration processes had slightly lower GWP emissions than the microturbine and the SOFC.

When comparing the TOPP and the AP emissions, in a typical day in January, the SOFC appeared to have the lowest TOPP and AP emissions followed by the microturbine, the 3-MW ICE, and the 143-kW ICE while the NGCC appeared to have the highest emissions after the average electric mix.

Figure 102 and Figure 103 show the normalized primary energy consumption and emissions from all processes in May and August respectively, where the cogeneration processes used electric chillers for cooling. In a typical day in May, the microturbine with EC had the highest energy consumption and GWP emissions. The 143-kW ICE (EC) had the second highest energy use followed by the average electric, the 3-MW ICE (EC), and the NGCC (EC), which had similar energy consumption to the SOFC (EC). The energy use profile in was similar to the GWP emissions except that the average electric mix exceeded the 143-kW ICE (EC) in GWP emissions.

As shown in Figure 102 and 103, in a typical day in May or August, the average electric mix had the highest TOPP and AP emissions when compared to the other processes. The SOFC (EC) had the lowest TOPP followed by the microturbine (EC), the 3-MW ICE (EC), whereas, the 143-kW ICE (EC) had approximately equal emissions to the NGCC. When comparing the AP of the cogeneration processes, they followed the same profile as with TOPP, with SOFC (EC) had the lowest AP emissions and the 143-kW ICE (EC) had the highest, after the average electric; however, the NGCC (EC) had the highest AP emissions when compared to all the cogeneration processes.

Figure 104 and Figure 105 show the normalized primary energy consumption and emissions from all processes in May and August, respectively, where the cogeneration processes used a combination of electric and absorption chillers for cooling. With the use of combination of absorption and electric chillers, all the cogeneration processes including the microturbine became attractive alternatives to the average electric mix because their primary energy consumption, GWP, TOPP, and AP were reduced. Nevertheless, the microturbine (AC/EC) and the 143-kW ICE (AC/EC) had relatively high energy consumption and GWP emissions, which was similar to the average electric mix.

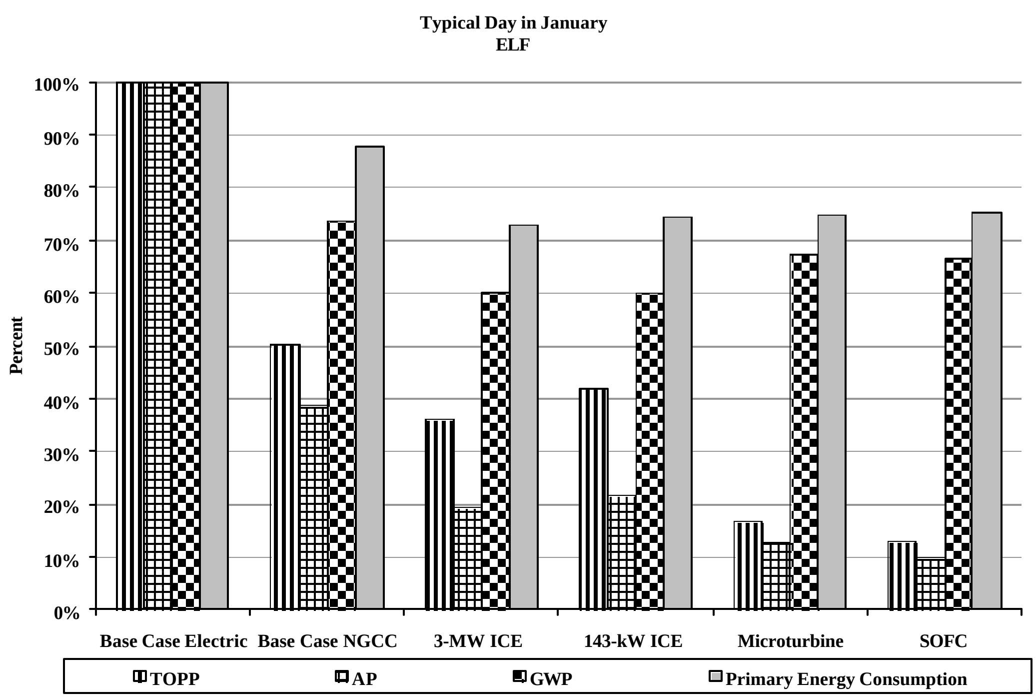

Figure 101: Normalized Primary Energy Consumption and Emissions in a Typical Day in January (ELF).

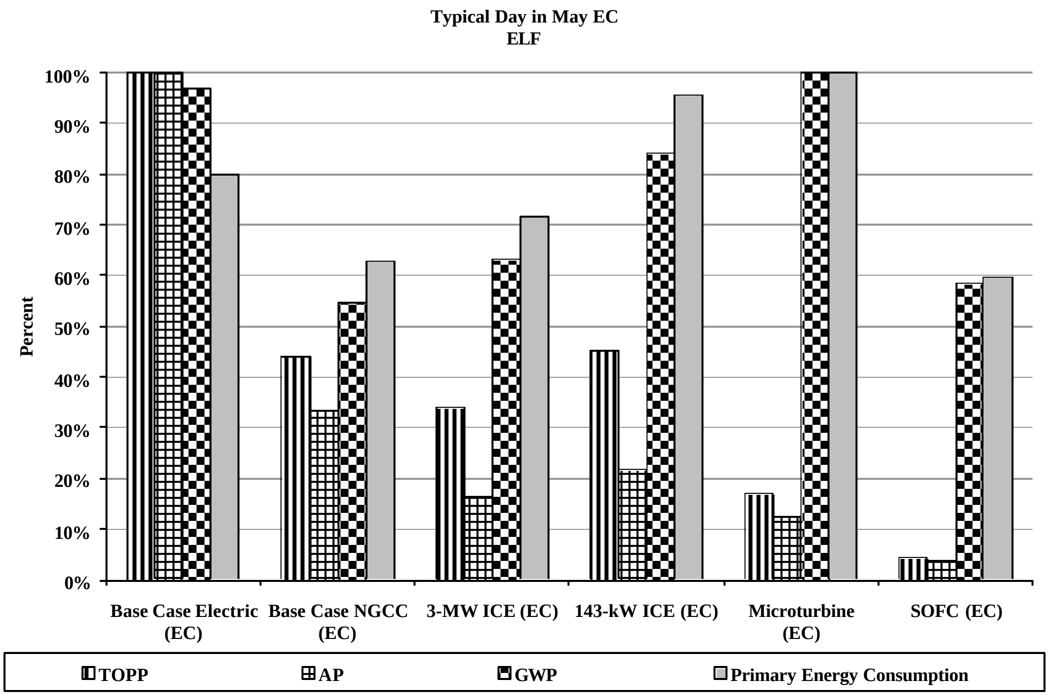

Figure 102: Normalized Primary Energy Consumption and Emissions in a Typical Day in May (ELF). Cooling is met by electric chillers.

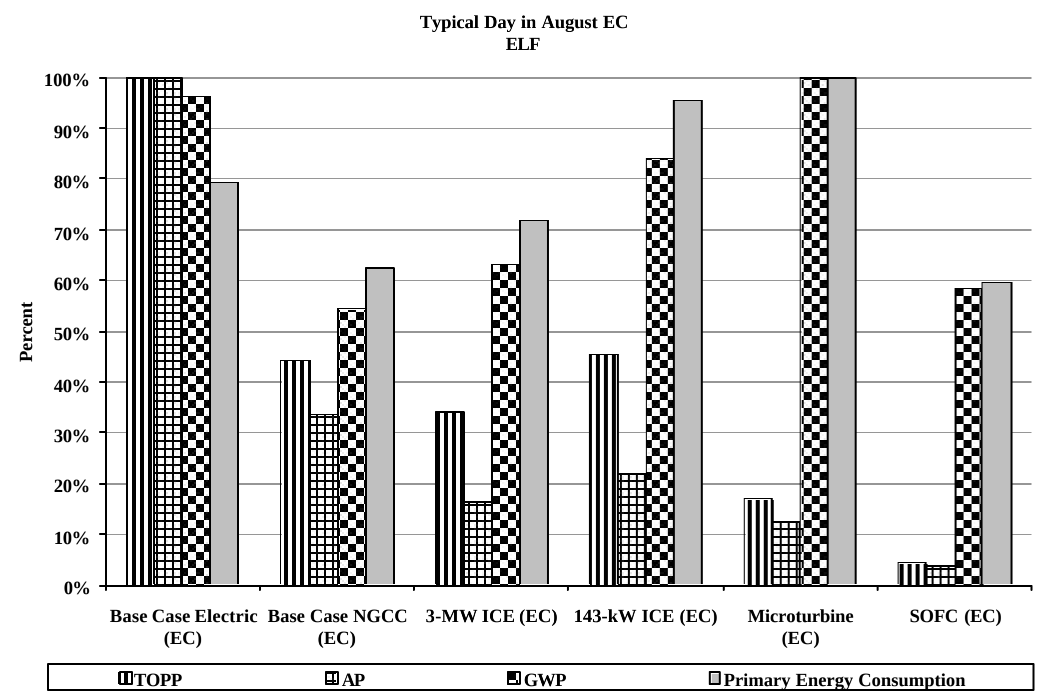

Figure 103: Normalized Primary Energy Consumption and Emissions in a Typical Day in August (ELF). Cooling is met by electric chillers.

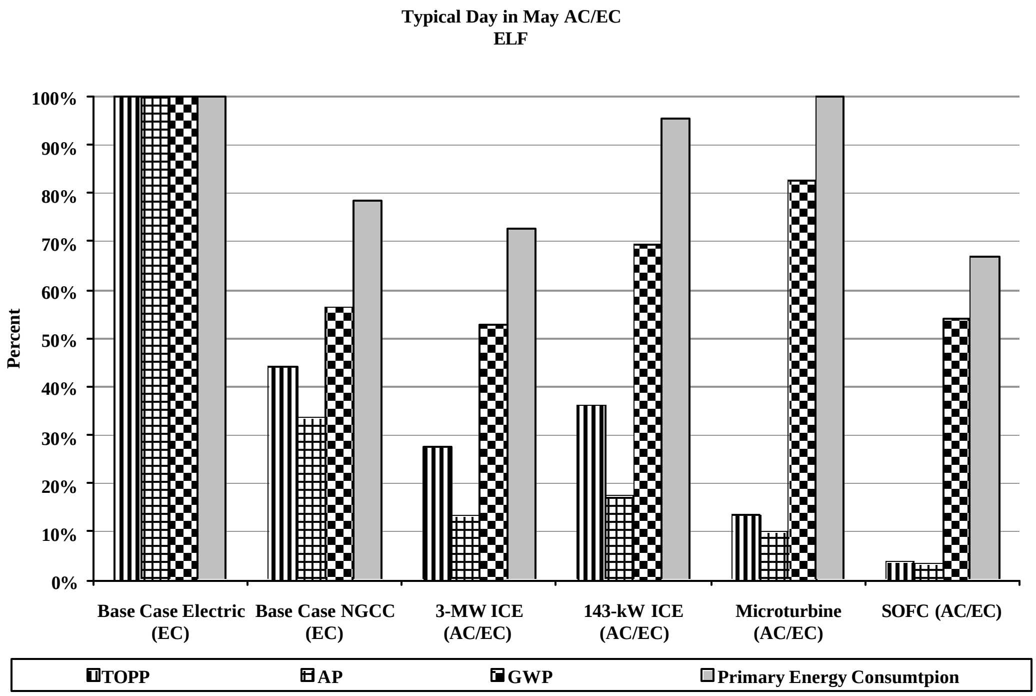

Figure 104: Normalized Primary Energy Consumption and Emissions in a Typical Day in May (ELF). Cooling is met by a combination of absorption and electric chillers.

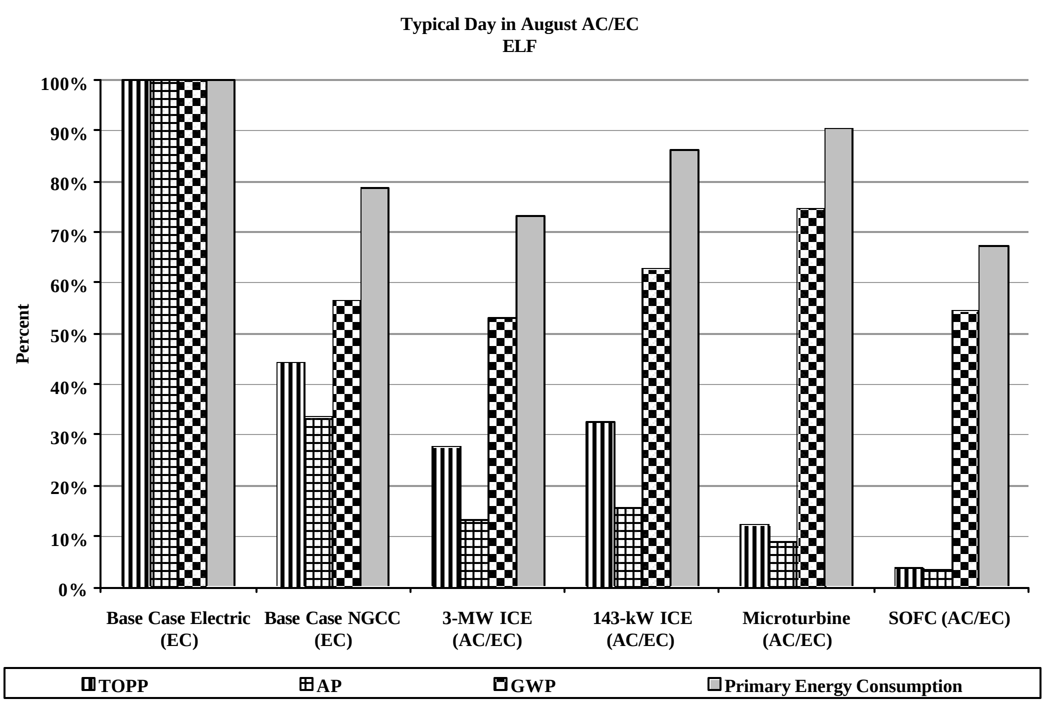

Figure 105: Normalized Primary Energy Consumption and Emissions in a Typical Day in August (ELF). Cooling is met by a combination of absorption and electric chillers.

5.5.3 Summary (ELF)

For the annual scenarios, the two systems considered for cooling were:

(a) absorption chillers (AC), cogeneration systems followed the electric load of the building consisting of equipment, ventilation, and lighting, and the co-generated heat was used to drive the AC; and

(b) electric chillers (EC), cogeneration systems followed the electric load of the building consisting of equipment, ventilation, lighting, and cooling with EC.

From the analysis of the results, the microturbine (AC), microturbine (EC), 143-kW ICE (AC) and 143-kW ICE (EC), produced about three times the heating energy demand of the building. Also, the microturbine and 143-kW ICE with AC were able to produce sufficient thermal energy to meet the cooling, as well as, the space and water heating demand of the building. This was mainly because of their relatively high thermal efficiencies. On the other hand, the 3-MW ICE (AC) was not able to generate sufficient thermal energy to meet the cooling energy use of the building but both the 3-MW ICE (AC) and the 3-MW ICE (EC) were able to meet the space and water heating energy use of the building. The SOFC (EC) was able to meet the space and water heating energy use of the building, however, the SOFC (AC) produced only half the amount of heat required for the cooling and heating loads.

The analysis of the daily thermal generation, (where thermal storage was assumed over a typical day in a month), from the cogeneration processes showed that in January, while following the electric load of the building (office equipment and lighting), all cogeneration processes required supplemental heat to meet the thermal demand of the building (space and water heating). Supplemental heat was generated from gas boilers. Heat production from the cogeneration processes followed their thermal efficiencies: the microturbine co-generated more thermal energy than the 143-kW ICE, followed by the 3-MW ICE and the SOFC; their respective thermal efficiencies are: 52%, 51%, 41%, and 26%.

In May and August, as the electric energy use of the building (cooling, office equipment, and lighting) increased compared to January, all cogeneration processes produced more thermal energy than required by the building, mainly water heating. Similar to January, the thermal energy production from the cogeneration processes corresponded to their thermal efficiencies.

The results from the hourly scenarios analysis, (no thermal storage was considered over the day), showed that the hourly heat production from the cogeneration processes followed the electric energy load profile of the building. The analysis of heat generation from the cogeneration processes showed that heat generation in all months (January, May, and August) was low during the early and late hours of the day and peaks during the working hours of the day (hours 8-17), which corresponded to the peaks of the electric energy use of the building. Although all cogeneration processes failed to meet the thermal demand of the building over a typical day in January, the analysis of the hourly heat production from cogeneration processes showed that cogeneration processes with higher thermal efficiency ratios, such as the microturbine and the 143-kW ICE were able to meet the thermal demand during the working hours of the day.

The three options considered to operate the cogeneration processes were:

(a) Operate the cogeneration processes to meet the electric load of the building and the cooling load was met by electric chillers run by cogeneration processes,

(b) Operate the cogeneration processes to meet the electric load of the building, which consisted of equipment and lighting. Part of the co-generated heat was used to meet the thermal energy use of the building (mainly water heating) and the remaining heat was used to drive the absorption chillers to meet part/all of cooling energy use of the building. Any unmet cooling load was satisfied by operating the cogeneration processes to produce sufficient heat to run the absorption chillers.

If the thermal energy produced by a cogeneration process was less than the thermal energy use of the building, a gas boiler can be used to meet the thermal demand and the cogeneration process was operated to meet the cooling load by running an absorption chiller, and

(c) Operate the cogeneration processes to meet the electric load of the building, which consisted of equipment and lighting. Part of the co-generated heat was used to meet the thermal energy use of the building (mainly water heating) and the remaining heat was used to drive absorption chillers to meet part/all of cooling energy use of the building. Any unmet cooling load was satisfied by operating the cogeneration processes to run a combination of electric and absorption chillers.

In January, the average electric mix had the highest primary energy consumption, GWP, TOPP, and AP compared to the other processes. Although the SOFC had the highest electrical efficiency compared to the other cogeneration processes, its primary energy consumption and GWP was relatively high and comparable to other cogeneration processes, even those with lower electrical efficiencies, such as the microturbine and the 143-kW ICE. This was mainly because the SOFC co-generated low thermal energy and required supplemental heat to meet the thermal demand of the building in January. Approximately all cogeneration processes had equal primary energy consumption in January but the 3-MW ICE and the 143-kW ICE had slightly lower GWP than the SOFC and the microturbine. The NGCC had slightly higher primary energy consumption and GWP than the cogeneration processes.

When comparing the TOPP and AP of the cogeneration processes in January, the SOFC had the lowest TOPP and AP followed by the microturbine, and the 143-kW ICE, which was relatively similar to the 3-MW ICE. The NGCC had relatively higher TOPP and AP compared to the cogeneration processes.

In summer months (May and August), when the cogeneration processes used electric chillers to meet the cooling energy use of the building, they consumed relatively higher primary energy and produced relatively higher emissions than when utilizing the co-generated heat by running absorption chillers to meet the cooling load.

In May and August, the SOFC had the lowest primary energy consumption and emissions when compared to other processes. It had similar energy consumption and GWP emissions as the NGCC and the 3-MW ICE (using a combination of AC and EC), mainly because these processes had similar electrical efficiency: the electrical efficiency of the SOFC was 47%, the 3-MW ICE was 39%, and the NGCC was 49%. In addition, the SOFC had the lowest TOPP and

AP emissions relative to the other processes because the main emissions from the SOFC were carbon dioxide, originating from hydrogen gas reforming of natural gas.

When comparing cogeneration processes using a combination of AC and EC, in May and August, as shown in Figures 104 and 105, the SOFC and the 3-MW ICE had approximately equal primary energy consumption and GWP while the 143-kW ICE and the microturbine were similar. The SOFC and the microturbine had similar energy consumption to the NGCC while the microturbine and the 143-kW ICE had similar consumption to the average electric mix. However, the average electric mix had comparatively higher GWP than all the other cogeneration processes with AC/EC.

Similar to January, the microturbine and the SOFC had lower TOPP and AP than the 3-MW ICE and the 143-kW ICE. The NGCC had slightly higher TOPP and AP than the 3-MW ICE (AC/EC) and the 143-kW ICE (AC/EC) while the average electric mix had the highest TOPP and AP in all months. Refer to Figures 104 and 105.

In May and August, using a combination of AC and EC for all the cogeneration processes, except for processes with low thermal efficiency ratios, such as the SOFC, was important, when considering the overall efficiencies of the cogeneration processes, which resulted in significant reduction in energy consumption and emissions, especially with GWP emissions.

Generally, for electrical load following cases, while the electrical efficiency of a system determined the amount of electricity generated from it and subsequently the amount of energy consumed and emissions produced, the thermal efficiency of the system affected the magnitude of reduction in energy consumption and emissions. This was illustrated by the SOFC, which had relatively high electrical efficiency (47%) and low thermal efficiency (26%), and the microturbine, which had relatively low electrical efficiency (28%) and high thermal efficiency (52%). While there was no noticeable reduction in energy consumption and emissions from the SOFC when using EC versus a combination of AC and EC, there was a significant reduction in energy consumption and emissions from the microturbine when a combination of AC and EC were used versus the EC alone, as shown in Figures 97-100. This was because the low thermal energy produced from the SOFC was not a significant source of energy to run an AC, whereas, the high thermal output from the microturbine was efficiently utilized in running the AC, and consequently reducing the primary energy consumption and emissions from the process.

There were some differences between the annual and daily energy consumption and emissions from the cogeneration processes. For instance, the annual results showed that the SOFC (EC) had the lowest primary energy consumption and GWP when compared to the other processes but when analyzing the daily results, there was negligible difference in primary energy consumption and GWP between all cogeneration processes in January, and differences in energy consumption and GWP were only seen in May and August. This was because in January the SOFC required supplemental heat to meet the thermal demand of the building because of its low thermal output. On the other hand, in May and August, because the thermal load of the building was low, the SOFC (EC) was able to meet the thermal demand of the building; in addition, because of its high electrical efficiency compared to the other cogeneration processes, it had relatively low primary energy consumption and GWP.

Therefore, when considering GWP and primary energy consumption, the SOFC presented an attractive alternative to other cogeneration processes (ELF) only when the thermal demand was low. Also, cogeneration processes with relatively high thermal efficiency ratios, such as the microturbine and the 143-kW ICE were able to increase their overall system's efficiency when they utilized their thermal output for heating purposes and when using absorption chillers or combination of absorption and electric chillers, instead of electric chillers only for cooling purposes. Another deduction that could be made from the results is that it was not efficient to use an absorption chiller or a combination of absorption and electric chillers with the SOFC because of the low thermal output from the SOFC, which was not utilized effectively with absorption chillers.

6.0 CONCLUSION & FUTURE RESEARCH

This chapter consists of the following sections:

Section 6.1

This section provides the main conclusion of the study.

Section 6.2

This section includes some suggestions for future research.

6.1 Conclusion

The current study shows that generally natural gas-fired systems for thermal and electric energy generation are attractive alternatives to conventional grid electric systems from the environmental impact perspective. Before generalizing the results of this study, the study boundaries, assumptions and limitations of the study should be considered. The scope of this study was limited by the geographic, climatic, and technology coverage, and operational strategies. Some of the main limitations of this study are:

- The environmental impact indicators used in this study do not represent a comprehensive environmental impact analysis but were chosen to provide a general understanding of the performance of energy systems in buildings and to target ways to minimize the environmental impacts of their use. A comprehensive environmental impact analysis, including economic impacts and other parameters, would be valuable, especially if the study was done on an actual setting;
- The study presents a generalized hypothetical case and results might not apply to real life scenarios; and
- Energy system performance depended on building load characteristics, technology specifications, and operational strategies, and therefore these systems could operate differently under different circumstances.

The application of the life cycle assessment framework offered more insight on the systems performance and applicability of the operational strategies for the cogeneration systems considered in the study illustrated by the analysis of the primary energy use, GWP, TOPP, and AP.

A commercial office building was used as a hypothetical case study to examine operational strategies for cogeneration systems and simulation software was used to generate the building's cooling, heating, and electrical energy usage. The building's energy usage data were used in conjunction with upstream process descriptions to create the life cycle assessment model.

From the analysis of the results, the performance of the cogeneration systems was found to be generally affected by:

(a) the building's load characteristics, and

(b) the thermal and electrical efficiency ratios of a cogeneration process.

The building's load characteristics were important in identifying opportunities for optimizing the operational strategies of the cogeneration systems. Furthermore, there were key differences between data from annual energy use and daily or/and hourly energy use of the building. Such differences had a great impact on the optimization of the operation strategies; for instance, annual results did not show the difference in electric use during the hours of a day, whereas, the hourly energy use showed when the electric use was low and when it was high during a day. By knowing that, a cogeneration system could be operated efficiently during hours of need instead of during the whole day. In addition, by analyzing the building's energy use, decisions could be made on identifying the appropriate cogeneration system for operation, because not all the cogeneration processes function similarly. For instance, the SOFC modeled in the study was more efficient when used to follow the electric load of the building, whereas, it was not efficient when used to follow the thermal load.

The thermal and electrical efficiency ratios of the cogeneration processed determined the quantity of the thermal and electrical energy generated. Processes with relatively high thermal efficiencies produced higher thermal energy than those with lower ones and similarly processes with relatively high electrical efficiencies produced higher electrical energy than those with lower ones. Moreover, in cogeneration processes, both the thermal and electrical efficiency ratios were important factors when considering the total efficiency of the system since both thermal and electrical outputs from a cogeneration process were used to meet a specific load. For instance, cogeneration processes with relatively high thermal efficiency ratios, such as the microturbine model used in the study (52%) and low electrical efficiency (28%), were not able to meet the electrical demand of the building, because they co-generated low thermal energy when the electrical load was low, such as in cooling months, and required supplemental electricity.

While the analysis of the energy use of the building and the co-generated electric and thermal energy from a cogeneration process, (following the thermal and electric load of the building), helped in identifying efficient approaches for operation, allocating and quantifying emissions from the processes helped in understanding systems performance, specific sources and causes of emissions, and possibly would allow to identify ways to minimize the environmental impacts from such processes in the future.

In both electrical and thermal load following cases, generally the GWP emission distribution from the cogeneration processes was about 90% CO_2, about 10% CH_4, and 0.1-0.06 N_2O (depending on the process). The CO_2 emissions from the 143-kW ICE, the 3-MW ICE, and the microturbine originated mainly from the cogeneration combustion process, when supplemental electricity or supplemental heat were not required in thermal and electrical load following cases, respectively. However, when the electric or thermal energy generated from the cogeneration processes were not sufficient to meet the electric and thermal loads of the building and supplemental electricity from the average electric mix, or supplemental heat from gas boilers were required to meet the demand, some of the CO_2 emissions originated from upstream electric generation processes, associated with the average electric mix, in the case of supplemental electric requirement, or from the gas boilers, in the case of supplemental heat requirement.

The CH_4 emissions originated mainly from upstream processes, such as gas extraction, distribution, and processing. With both the ICE processes, most of the N_2O emissions originated from the cogeneration combustion processes; whereas, both the microturbine and the SOFC combustion processes produced negligible N_2O emissions as most of the N_2O emissions originated from upstream electric and thermal generation processes.

Generally, the TOPP and AP emission distribution from the cogeneration processes were mainly NOx (about 60-90%). Most of the NOx emissions originated from the cogeneration combustion processes except for the SOFC, where the TOPP and AP emissions originated mainly from the gas turbine compressor and other upstream processes.

For the current study, electrical load following was found to be the optimal operational strategy for all cogeneration systems, from the environmental impact perspective. Under the assumptions considered in this study, the main findings were that cogeneration systems performed better with ELF when the thermal load of the building was high; energy consumption and emissions were reduced when AC or combination of AC and EC were used for cooling with cogeneration systems, except for the SOFC, which performed equally well with EC only; and the

3-MW ICE (ELF) using combination of AC and EC, and the SOFC using EC (ELF) showed the best performance compared to the other systems.

In some applications, conventional grid power systems might be less laborious when considering maintenance, variable loads, and utility interconnections. However, power from the grid has been proven to be unreliable, and moreover, is an inefficient and problematic source of energy from the environmental impact perspective. Cogeneration systems could be beneficial alternatives to the conventional grid power when considering efficient energy use because cogeneration systems allow for the utilization of the otherwise wasted heat from a process produced during electric generation. Efficient energy use translates into reduction in primary energy consumption and lower emissions from energy generating systems. Hence, whether the criteria is reducing non-renewable resource use, local smog formation in ozone non-attainment areas, regional acidification potential, or global warming potential, cogeneration systems can provide a potential to achieve such goals.

6.2 Future Research

Additional research is required in the following areas:

- Examine other environmental impact parameters, such as economic impact.
- Perform comparative analysis of the effect of various climates on the energy systems' performance.
- Model different building types and characteristics and analyze their electric and thermal energy use.
- Improve life cycle assessment study by refining upstream data that reflect specific locations, climates, technologies etc.
- Investigate other modes of energy systems operations, such as peak shaving etc., and examine the effects of thermal and electrical storage on the overall systems efficiencies and environmental impact.

APPENDIX A

List of Scenarios & Processes

List of Scenarios

1. **Baseline average electric- Hourly-January:** Electric energy use of the building was satisfied by average electric mix during a typical day in January.
2. **Baseline average electric (EC) Hourly-May:** Electric energy use of the building was satisfied by average electric mix and cooling load was met by an electric chiller during a typical day in May.
3. **Baseline average electric (AC) Hourly-May:** Electric energy use of the building was satisfied by average electric mix and cooling load was met by an absorption chiller during a typical day in May.
4. **Baseline average electric (EC) Hourly-August:** Electric energy use of the building was satisfied by average electric mix and cooling load was met by an electric chiller during a typical day in August.
5. **Baseline average electric (AC) Hourly-August:** Electric energy use of the building was satisfied by average electric mix and cooling load was met by an absorption chiller during a typical day in August.
6. **Baseline NGCC-Hourly-January:** Electric energy use of the building was satisfied by NGCC during a typical day in January.
7. **Baseline NGCC (EC) Hourly-May:** Electric energy use of the building was satisfied by NGCC and cooling load was met by an electric chiller during a typical day in May.
8. **Baseline NGCC (AC) Hourly-May:** Electric energy use of the building was satisfied by NGCC and cooling load was met by an absorption chiller during a typical day in May.
9. **Baseline NGCC (EC) Hourly-August:** Electric energy use of the building was satisfied by NGCC and cooling load was met by an electric chiller during a typical day in August.
10. **Baseline NGCC (AC) Hourly-August:** Electric energy use of the building was satisfied by NGCC and cooling load was met by an absorption chiller during a typical day in August.
11. **Microturbine (EBL) Hourly-January:** Electric energy use of the building was satisfied by microturbine during a typical day in January.
12. **Microturbine (TBL) Hourly-January:** Thermal energy use of the building was satisfied by microturbine during a typical day in January.

13. **Microturbine (EBL) Hourly-May (EC):** Electric energy use of the building was satisfied by microturbine and cooling load was satisfied by an electric chiller run by the microturbine during a typical day in May.
14. **Microturbine (EBL) Hourly-May (EC/AC):** Electric energy use of the building was satisfied by microturbine and cooling load was satisfied by a combination of electric and absorption chillers run by the microturbine during a typical day in May.
15. **Microturbine (TBL) Hourly-May (AC):** Thermal energy use of the building was satisfied by microturbine and cooling load was satisfied by an absorption chiller run by the microturbine during a typical day in May.
16. **Microturbine (EBL) Hourly-August (EC):** Electric energy use of the building was satisfied by microturbine and cooling load was satisfied by an electric chiller run by the microturbine during a typical day in August.
17. **Microturbine (EBL) Hourly-August (EC/AC):** Electric energy use of the building was satisfied by microturbine and cooling load was satisfied by a combination of electric and absorption chillers run by the microturbine during a typical day in August.
18. **Microturbine (TBL) Hourly-August (AC):** Thermal energy use of the building was satisfied by microturbine and cooling load was satisfied by an absorption chiller run by the microturbine during a typical day in August.
19. **3-MW ICE (EBL) Hourly-January:** Electric energy use of the building was satisfied by a 3-MW ICE during a typical day in January.
20. **3-MW ICE (TBL) Hourly-January:** Thermal energy use of the building was satisfied by a 3-MW ICE during a typical day in January.
21. **3-MW ICE (EBL) Hourly-May (EC):** Electric energy use of the building was satisfied by a 3-MW ICE and the cooling load was satisfied by an electric chiller run by the 3-MW ICE during a typical day in May.
22. **3-MW ICE (EBL) Hourly-May (EC/AC):** Electric energy use of the building was satisfied by a 3-MW ICE and the cooling load was satisfied by a combination of electric and absorption chillers run by the 3-MW ICE during a typical day in May.
23. **3-MW ICE (TBL) Hourly-May (AC):** Thermal energy use of the building was satisfied by a 3-MW ICE and the cooling load was satisfied by an absorption chiller run by the 3-MW ICE during a typical day in May.
24. **3-MW ICE (EBL) Hourly-August (EC):** Electric energy use of the building was satisfied by a 3-MW ICE and the cooling load was satisfied by an electric chiller run by the 3-MW ICE during a typical day in August.
25. **3-MW ICE (EBL) Hourly-August (EC/AC):** Electric energy use of the building was satisfied by a 3-MW ICE and the cooling load was satisfied by a combination of electric and absorption chillers run by the 3-MW ICE during a typical day in August.
26. **3-MW ICE (TBL) Hourly-August (AC):** Thermal energy use of the building was satisfied by a 3-MW ICE and the cooling load was satisfied by an absorption chiller run by the 3-MW ICE during a typical day in August.
27. **143-kW ICE (EBL) Hourly-January:** Electric energy use of the building was satisfied by a 143-kW ICE during a typical day in January.

28. **143-kW ICE (TBL) Hourly-January:** Thermal energy use of the building was satisfied by a 143-kW ICE during a typical day in January.
29. **143-kW ICE (EBL) Hourly-May (EC):** Electric energy use of the building was satisfied by a 143-kW ICE and the cooling load was satisfied by an electric chiller run by the 143-kW ICE during a typical day in May.
30. **143-kW ICE EBL Hourly-May (EC/AC):** Electric energy use of the building was satisfied by a 143-kW ICE and the cooling load was satisfied by a combination of electric and absorption chillers run by the 143-kW ICE during a typical day in May.
31. **143-kW ICE (TBL) Hourly-May (AC):** Thermal energy use of the building was satisfied by a 143-kW ICE and the cooling load was satisfied by an absorption chiller run by the 143-kW ICE during a typical day in May.
32. **143-kW ICE (EBL) Hourly-August (EC):** Electric energy use of the building was satisfied by a 143-kW ICE and the cooling load was satisfied by an electric chiller run by the 143-kW ICE during a typical day in August.
33. **143-kW ICE (EBL) Hourly-August (EC/AC):** Electric energy use of the building was satisfied by a 143-kW ICE and the cooling load was satisfied by a combination of electric and absorption chillers run by the 143-kW ICE during a typical day in August.
34. **143-kW ICE (TBL) Hourly-August (AC):** Thermal energy use of the building was satisfied by a 143-kW ICE and the cooling load was satisfied by an absorption chiller run by the 143-kW ICE during a typical day in August.
35. **SOFC (EBL) Hourly-January:** Electric energy use of the building was satisfied by a SOFC during a typical day in January.
36. **SOFC (TBL) Hourly-January:** Thermal energy use of the building was satisfied by a SOFC during a typical day in January.
37. **SOFC (EBL) Hourly-May (EC):** Electric energy use of the building was satisfied by a SOFC and the cooling load was satisfied by an electric chiller run by the SOFC during a typical day in May.
38. **SOFC (EBL) Hourly-May (EC/AC):** Electric energy use of the building was satisfied by a SOFC and the cooling load was satisfied by a combination of electric and absorption chillers run by the SOFC during a typical day in May.
39. **SOFC (TBL) Hourly-May (AC):** Thermal energy use of the building was satisfied by a SOFC and the cooling load was satisfied by an absorption chiller run by the SOFC during a typical day in May.
40. **SOFC (EBL) Hourly-August (EC):** Electric energy use of the building was satisfied by a SOFC and the cooling load was satisfied by an electric chiller run by the SOFC during a typical day in August.
41. **SOFC (EBL) Hourly-August (EC/AC):** Electric energy use of the building was satisfied by a SOFC and the cooling load was satisfied by a combination of electric and absorption chillers run by the SOFC during a typical day in August.
42. **SOFC (TBL) Hourly-August (AC):** Thermal energy use of the building was satisfied by a SOFC and the cooling load was satisfied by an absorption chiller run by the SOFC during a typical day in August.

43. **Typical Day in January (EBL):** Electric energy use of the building was satisfied by five options (average electric mix, NGCC, microturbine, SOFC, 3-MW ICE and 143-kW ICE) in a typical day in January.
44. **Typical Day in January (TBL):** Thermal energy use of the building was satisfied by five options (average electric mix, NGCC, microturbine, SOFC, 3-MW ICE and 143-kW ICE) in a typical day in January.
45. **Typical Day in May (EBL) (EC):** Electric energy use of the building was satisfied by five options (average electric mix, NGCC, microturbine, SOFC, 3-MW ICE and 143-kW ICE) and cooling load was satisfied by electric chillers in a typical day in May.
46. **Typical Day in May (EBL) (EC/AC):** Electric energy use of the building was satisfied by five options (average electric mix, NGCC, microturbine, SOFC, 3-MW ICE and 143-kW ICE) and cooling load was satisfied by combination of electric and absorption chillers in a typical day in May.
47. **Typical Day in May (TBL) (AC):** Thermal energy use of the building was satisfied by five options (average electric mix, NGCC, microturbine, SOFC, 3-MW ICE and 143-kW ICE) and cooling load was satisfied by absorption chillers in a typical day in May.
48. **Typical Day in August (EBL) (EC):** Electric energy use of the building was satisfied by five options (average electric mix, NGCC, microturbine, SOFC, 3-MW ICE and 143-kW ICE) and cooling load was satisfied by electric chillers in a typical day in August.
49. **Typical Day in August (EBL) (EC/AC):** Electric energy use of the building was satisfied by five options (average electric mix, NGCC, microturbine, SOFC, 3-MW ICE and 143-kW ICE) and cooling load was satisfied by combination of electric and absorption chillers in a typical day in August.
50. **Typical Day in August (TBL) (AC):** Thermal energy use of the building is satisfied by five options (average electric mix, NGCC, microturbine, SOFC, 3-MW ICE and 143-kW ICE) and cooling load is satisfied by absorption chillers in a typical day in August.
51. **Typical Year:** TLF, with AC for cooling in May and August, and ELF, with EC for cooling in May and August, scenarios for SOFC, 3-MW ICE, 143-kW ICE, and microturbine were created for a typical year, in addition to four options of conventional systems: average electric mix with AC and with EC; and NGCC with AC and with EC.

List of Processes[2]

1. **Absorption Chiller (2% Copper) COP 1.05-3-MW ICE:** Absorption chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 1.05. Input heat is generated from a 3-MW ICE.
2. **Absorption Chiller (2% Copper) COP 1.05-143-kW ICE:** Absorption chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 1.05. Input heat is generated from a 143-kW ICE.
3. **Absorption Chiller (2% Copper) COP 1.05-Microturbine:** Absorption chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 1.05. Input heat is generated from a microturbine.
4. **Absorption Chiller (2% Copper) COP 1.05-SOFC:** Absorption chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 1.05. Input heat is generated from a SOFC.
5. **Absorption Chiller (2% Copper) COP 1.05-Gas Boiler:** Absorption chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 1.05. Input heat is generated from a gas boiler.
6. **Absorption Chiller (2% Copper) COP 1.0-Gas Boiler:** Absorption chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 1.0. Input heat is generated from a gas boiler.
7. **Absorption Chiller (2% Copper) COP 1.1-Gas Boiler:** Absorption chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 1.1. Input heat is generated from a gas boiler.
8. **Absorption Chiller (5% Copper) COP 1.05-Gas Boiler:** Absorption chiller process; auxiliary materials are assumed to be made of 5% copper and 95% steel and the coefficient of performance (COP) is assumed to be 1.05. Input heat is generated from a gas boiler.
9. **Absorption Chiller (5% Copper) COP 1.0-Gas Boiler:** Absorption chiller process; auxiliary materials are assumed to be made of 5% copper and 95% steel and the coefficient of performance (COP) is assumed to be 1.0. Input heat is generated from a gas boiler.
10. **Absorption Chiller (5% Copper) COP 1.1-Gas Boiler:** Absorption chiller process; auxiliary materials are assumed to be made of 5% copper and 95% steel and the coefficient of performance (COP) is assumed to be 1.1. Input heat is generated from a gas boiler.
11. **Absorption Chiller (100% Steel) COP 1.05-Gas Boiler:** Absorption chiller process; auxiliary materials are assumed to be made of 100% steel and the coefficient of

[2] Notice that these list of processes were created in GEMIS (user defined) but there were other linked processes obtained from the software that are not included in this list but are presented in the process trees in Appendix J.

performance (COP) is assumed to be 1.05. Input heat is generated from a gas boiler.

12. **Absorption Chiller (100% Copper) COP 1.0-Gas Boiler:** Absorption chiller process; auxiliary materials are assumed to be made of 100% steel and the coefficient of performance (COP) is assumed to be 1.0. Input heat is generated from a gas boiler.
13. **Absorption Chiller (100% Copper) COP 1.1-Gas Boiler:** Absorption chiller process; auxiliary materials are assumed to be made of 100% steel and the coefficient of performance (COP) is assumed to be 1.1. Input heat is generated from a gas boiler.
14. **Electric Chiller (2% Copper)-US Average:** Electric chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 4.58. Input electricity is generated from US average electric mix.
15. **Electric Chiller (5% Copper)-US Average:** Electric chiller process; auxiliary materials are assumed to be made of 5% copper and 95% steel and the coefficient of performance (COP) is assumed to be 4.58. Input electricity is generated from US average electric mix.
16. **Electric Chiller (100% Steel)-US Average:** Electric chiller process; auxiliary materials are assumed to be made of 100% steel and the coefficient of performance (COP) is assumed to be 4.58. Input electricity is generated from US average electric mix.
17. **Electric Chiller (2% Copper)-NGCC:** Electric chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 4.58. Input electricity is generated from NGCC.
18. **Electric Chiller (5% Copper)-NGCC:** Electric chiller process; auxiliary materials are assumed to be made of 5% copper and 95% steel and the coefficient of performance (COP) is assumed to be 4.58. Input electricity is generated from NGCC.
19. **Electric Chiller (100% Steel)-NGCC:** Electric chiller process; auxiliary materials are assumed to be made of 100% steel and the coefficient of performance (COP) is assumed to be 4.58. Input electricity is generated from NGCC.
20. **Electric Chiller (2% Copper)-3-MW ICE:** Electric chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 4.58. Input electricity is generated from 3-MW ICE.
21. **Electric Chiller (2% Copper)-143-kW ICE:** Electric chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 4.58. Input electricity is generated from 143-kW ICE.
22. **Electric Chiller (2% Copper)-Microturbine:** Electric chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of performance (COP) is assumed to be 4.58. Input electricity is generated from microturbine.
23. **Electric Chiller (2% Copper)-SOFC:** Electric chiller process; auxiliary materials are assumed to be made of 2% copper and 98% steel and the coefficient of

performance (COP) is assumed to be 4.58. Input electricity is generated from SOFC.

24. **Electric Grid-US Average Electric:** Process for electric generation from US average electric mix including average grid loses of 6.5%.
25. **Electric Grid-NGCC:** Process for electric generation from NGCC including average grid loses of 6.5%.
26. **Gas Boiler:** Small gas-fired boiler for process heat.
27. **NGCC:** natural gas combined cycle process; electric efficiency is 49%.
28. **SOFC-Electrical:** SOFC process for generating electricity; electric efficiency 47%.
29. **SOFC-Thermal:** SOFC process for generating thermal energy; thermal efficiency 26%.
30. **SOFC-Thermal (33%):** SOFC process for generating thermal energy; thermal efficiency 33%.
31. **Microturbine-Electrical:** Microturbine process for generating electricity; electrical efficiency is 28%.
32. **Microturbine-Thermal:** Microturbine process for generating thermal energy; thermal efficiency is 52%.
33. **3-MW ICE-Electrical:** 3-MW ICE process for generating electricity; electrical efficiency is 39%.
34. **3-MW ICE-Thermal:** 3-MW ICE process for generating thermal energy; thermal efficiency is 41%.
35. **143-kW ICE-Electrical:** 143-kW ICE process for generating electricity; electrical efficiency is 29%.
36. **143-kW ICE-Electrical:** 143-kW ICE process for generating thermal energy; thermal efficiency is 51%.
37. **Reforming of NG to Hydrogen Gas:** process for reforming natural gas to hydrogen gas; 100% efficiency.

APPENDIX B

Emission Factors

Table B-7: Emission Factors from Natural Gas Combustion (EFIG, 1996).

Pollutant	Emission Factor (lb/106scf)	Emission Factor (lb/MMBtu)
NOx (expressed as NO2)		
Uncontrolled	1.00E+02	9.80E-02
controlled-Low NOx burners	5.00E+01	4.90E-02
controlled-Low NOx burners/FGR)	3.20E+01	3.14E-02
CO	8.40E+01	8.24E-02
CO2	1.20E+05	1.18E+02
N20		
Uncontrolled	2.20E+00	2.16E-03
Controlled	6.40E-01	6.27E-04
PM	7.60E+00	7.45E-03
SO2	6.00E-01	5.88E-04
CH4	2.30E+00	2.25E-03
TOC	1.10E+01	1.08E-02
VOC	5.50E+00	5.39E-03
Pb	5.00E-04	4.90E-07
Arsenic	2.00E-04	1.96E-07
Barium	4.40E-03	4.31E-06
Beryllium (<)	1.20E-05	1.18E-08
Cadmium	1.10E-03	1.08E-06
Chromium	1.40E-03	1.37E-06
Cobalt	8.40E-05	8.24E-08
Copper	8.50E-04	8.33E-07
Manganese	3.80E-04	3.73E-07
Mercury	2.60E-04	2.55E-07
Molybdenum	1.10E-03	1.08E-06

Nickel	2.10E-03	**2.06E-06**
Selenium (<)	2.40E-05	**2.35E-08**
Vanadium	2.30E-03	**2.25E-06**
Zinc	2.90E-02	**2.84E-05**

Table B-8: Uncontrolled Emission Factors for 4-Stroke Rich Burn Internal Combustion Engines (EFIG, 1996).

Pollutant	**Emission Factors (lb/MMBtu)**
SO2	5.88E-04
NOx	2.21
other particulates	9.50E-03
CO	3.72
NMVOC	1.1E-02 (from GEMIS)
CO2	1.10E+02
CH4	2.30E-01
N2O	3.66E-03 (from GEMIS)
Benzene	1.58E-03
Formaldehyde	2.05E-02
Toluene	5.58E-04
Xylene	1.95E-04

Table B-9: Uncontrolled Emission Factors for Stationary Gas Turbine (EFIG, 1996).

Pollutant	**Emission Factors (lb/MMBtu)**
SO2	3.4E-03
NOx	3.21E-01
PM	6.6E-03
CO	3.89E-01 (Capstone)
CO2	1.10E+02
CH4	2.30E-01
Benzene	1.2E-05
Formaldehyde	7.1E-04
Toluene	1.3E-04
Xylene	6.4E-05

Table B-10: Emission Factors for SOFC.

Pollutant	Emission Factors (lb/MMBtu)
NOx	1.7E-04 (IEA)
CO	2.0E-03 (IEA)
CO2	1.3E+02 (D Little, 2000)
NMVOC	4.0E-04 (IEA)

APPENDIX C

Commercial Building Energy Use Characteristics

Table C-11: Office Characteristics (Sezgen et al., 1995).

Table C.1. Office Prototype
Stock, Climate, Shell, Operation, and Lighting Characteristics

	Large Offices (>= 25,000 ft2)				Small Offices (< 25,000 ft2)			
	Stock		New		Stock		New	
	North U.S.	South U.S.	North U.S.	South U.S.	North U.S.	South U.S.	North U.S.	South U.S.
STOCK FLOOR AREA DATA								
Total area (million of ft2)	3822	4552	1117	1747	1210	2304	234	711
Percent of total U.S office area	32	38	9	15	10	19	2	6
LOCATION WEIGHT FACTORS								
Minneapolis	10	0	9	0	21	0	17	0
Chicago	55	0	58	0	67	0	93	0
Washington DC	41	21	50	13	31	12	17	14
Pasadena	0	55	0	55	0	45	0	51
Charleston	0	19	0	20	0	34	0	26
FLOOR-AREA WEIGHTED AVERAGES								
Building area (ft2)	111000	94000	137000	90000	5700	6000	6400	6600
Floors	7	6	7	6	2	1	2	1
SHELL								
Percent glass	45		50		20		15	
Window R-value	1.6	1.5	1.7	1.6	1.8	1.4	2.0	1.6
Window shading coefficient	0.8	0.77	0.69	0.71	0.79	0.82	0.71	0.75
Wall R-value	3.2	3.6	4.6	6.0	5.3	4.3	6.3	5.6
Roof R-value	9.5	11.6	9.1	12.6	12.0	11.3	13.3	12.6
Wall material	masonry				masonry			
Roof material	built-up				built-up			
OCCUPANCY								
Occupcy (ft2/pers)	430		390		440		470	
Weekday hours (hrs/day)	12				11			
Weekend hours (hrs/day)	5				4			
EQUIPMENT								
Power density (W/ft2)	0.75				0.5			
Full equipment hours (hrs/year)	3570				3380			
LIGHTING								
Power density (W/ft2)	1.8		1.3		2.2		1.7	
Full lighting hours (hrs/year)	4190				3340			

Table C-12: Electricity Overview (EIA, 2002).

Table 7.1 Electricity Overview

(Billion Kilowatthours)

	Net Generation						End Use		
	Electric Utilities	Nonutility Power Producers	Total	Imports[a]	Exports[a]	Losses and Unaccounted for[b]	Electric Utility Retail Sales[c]	Nonutility Power Producers[d]	Total[c]
1973 Total	**1,861**	**NA**	**1,861**	**17**	**3**	**NA**	**1,713**	**NA**	**NA**
1974 Total	**1,867**	**NA**	**1,867**	**15**	**3**	**NA**	**1,706**	**NA**	**NA**
1975 Total	**1,918**	**NA**	**1,918**	**11**	**5**	**NA**	**1,747**	**NA**	**NA**
1976 Total	**2,038**	**NA**	**2,038**	**11**	**2**	**NA**	**1,855**	**NA**	**NA**
1977 Total	**2,124**	**NA**	**2,124**	**20**	**3**	**NA**	**1,948**	**NA**	**NA**
1978 Total	**2,206**	**NA**	**2,206**	**21**	**1**	**NA**	**2,018**	**NA**	**NA**
1979 Total	**2,247**	**NA**	**2,247**	**23**	**2**	**NA**	**2,071**	**NA**	**NA**
1980 Total	**2,286**	**NA**	**2,286**	**25**	**4**	**NA**	**2,094**	**NA**	**NA**
1981 Total	**2,295**	**NA**	**2,295**	**36**	**3**	**NA**	**2,147**	**NA**	**NA**
1982 Total	**2,241**	**NA**	**2,241**	**33**	**4**	**NA**	**2,086**	**NA**	**NA**
1983 Total	**2,310**	**NA**	**2,310**	**39**	**3**	**NA**	**2,151**	**NA**	**NA**
1984 Total	**2,416**	**NA**	**2,416**	**42**	**3**	**NA**	**2,286**	**NA**	**NA**
1985 Total	**2,470**	**NA**	**2,470**	**46**	**5**	**NA**	**2,324**	**NA**	**NA**
1986 Total	**2,487**	**NA**	**2,487**	**41**	**5**	**NA**	**2,369**	**NA**	**NA**
1987 Total	**2,572**	**NA**	**2,572**	**52**	**6**	**NA**	**2,457**	**NA**	**NA**
1988 Total	**2,704**	**NA**	**2,704**	**39**	**7**	**NA**	**2,578**	**NA**	**NA**
1989 Total	**2,784**	[e]**188**	**2,972**	**26**	**15**	**236**	**2,647**	**100**	**2,747**
1990 Total	**2,808**	[e]**217**	**3,025**	**18**	**16**	**210**	**2,713**	**104**	**2,817**
1991 Total	**2,825**	[e]**246**	**3,071**	**22**	**2**	**218**	**2,762**	**111**	**2,873**
1992 Total	**2,797**	**286**	**3,083**	**28**	**3**	**224**	**2,763**	**122**	**2,885**
1993 Total	**2,883**	**314**	**3,197**	**31**	**4**	**236**	**2,861**	**127**	**2,988**
1994 Total	**2,911**	**343**	**3,254**	**47**	**2**	**223**	**2,935**	**141**	**3,075**
1995 Total	**2,995**	**363**	**3,358**	**43**	**4**	**235**	**3,013**	**149**	**3,162**
1996 Total	**3,077**	**370**	**3,447**	**43**	**3**	**237**	**3,101**	**149**	**3,250**
1997 Total	**3,123**	**372**	**3,494**	**43**	**9**	**234**	**3,146**	**149**	**3,295**
1998 Total	**3,212**	**406**	**3,618**	**40**	**13**	**220**	**3,264**	**160**	**3,424**
1999 Total	**3,174**	**531**	**3,705**	**43**	**14**	**233**	**3,312**	**189**	**3,501**
2000 January	266	58	324	4	1	NA	287	NA	NA
February	237	53	290	4	1	NA	271	NA	NA
March	241	53	295	4	1	NA	259	NA	NA
April	227	51	278	4	1	NA	246	NA	NA
May	254	58	312	4	1	NA	267	NA	NA
June	268	63	331	5	2	NA	299	NA	NA
July	279	74	353	5	1	NA	317	NA	NA
August	287	80	367	5	1	NA	331	NA	NA
September	245	74	319	4	1	NA	305	NA	NA
October	228	71	299	3	1	NA	274	NA	NA
November	227	71	297	4	1	NA	265	NA	NA
December	255	80	335	3	3	NA	292	NA	NA
Total	**3,015**	**785**	**3,800**	**49**	**15**	**213**	**3,413**	**208**	[E]**3,621**
2001 January	239	99	338	3	2	NA	310	NA	NA
February	203	86	289	3	3	NA	272	NA	NA
March	215	90	305	4	2	NA	268	NA	NA
April	200	82	282	4	2	NA	255	NA	NA
May	219	[R]88	307	4	2	NA	262	NA	NA
June	237	[R]95	331	4	1	NA	289	NA	NA
July	257	105	362	4	1	NA	316	NA	NA
August	262	111	373	4	1	NA	332	NA	NA
September	217	93	310	2	1	NA	296	NA	NA
October	206	90	296	2	1	NA	268	NA	NA
November	194	[R]86	280	2	1	NA	253	NA	NA
December	214	92	306	3	1	NA	265	NA	NA
Total	[R]**2,662**	[R]**1,117**	[R]**3,779**	**38**	**18**	**NA**	**3,385**	**NA**	**NA**
2002 January	[F]218	[F]97	[F]315	3	1	NA	[F]283	NA	NA

[a] Electricity transmitted across U.S. borders with Canada and Mexico.

[b] Energy losses that occur between the point of generation and delivery to the customer, and data collection frame differences and nonsampling error. See Note 12 at end of Section 2 for discussion on electrical system energy losses.

[c] Includes nonutility sales of electricity to utilities for distribution to end users. Beginning in 1996, also includes sales to ultimate consumers by power marketers. See box on Table 7.5 for additional information.

[d] Nonutility facility use of onsite net electricity generation, and nonutility sales of electricity to end users.

[e] Data for 1989-1991 were collected for facilities with capacities of 5 megawatts or more. In 1992, the threshold was lowered to include facilities with capacities of 1 megawatt or more. Estimates of the 1-to-5 megawatt range for 1989-1991 were derived from historical data. The estimation did not include retirements that occurred prior to 1992 and included only the capacity of facilities that came on line before 1992.

NA=Not available. E=Estimate. F=Forecast.

Notes: • Totals may not equal sum of components due to independent rounding. • Geographic coverage is the 50 states and the District of Columbia.

Sources: • **Net Generation:** Tables 7.2-7.4. • **Imports and Exports:** See end of section. • **Losses and Unaccounted for:** Calculated. • **End Use:** Table 7.5. **Forecast Values:** Derived from Energy Information Administration's Short-Term Integrated Forecasting System. See related note on page 79 (Note 9).

Table C-13: Natural Consumption in Buildings (U.S. DOE, 1995)

Table 20. Total Natural Gas Consumption and Expenditures, 1995

Building Characteristics	All Buildings Using Natural Gas			Natural Gas Consumption		Natural Gas Expenditures	
	Number of Buildings (thousand)	Floorspace (million square feet)	Floorspace per Building (thousand square feet)	Total (trillion Btu)	Total (billion cubic feet)	Total (million dollars)	RSE Row Factor
RSE Column Factor:	1.1	0.9	0.7	1.1	1.1	1.2	
All Buildings	2,478	38,145	15.4	1,946	1,895	9,018	4.80
Building Floorspace (square feet)							
1,001 to 5,000	1,112	2,942	2.6	264	257	1,483	8.13
5,001 to 10,000	614	4,497	7.3	272	264	1,439	10.91
10,001 to 25,000	474	7,561	16.0	356	347	1,775	9.22
25,001 to 50,000	146	5,242	36.0	231	225	1,159	6.43
50,001 to 100,000	82	5,608	68.8	243	237	1,091	6.52
100,001 to 200,000	33	4,643	139.2	244	238	958	8.60
200,001 to 500,000	13	3,941	295.6	211	205	729	9.07
Over 500,000	4	3,712	882.3	125	122	385	10.92
Principal Building Activity							
Education	204	5,800	28.4	245	239	1,117	9.64
Food Sales	58	401	6.9	18	17	97	27.14
Food Service	184	1,001	5.4	158	154	851	17.04
Health Care	51	1,759	34.3	258	252	838	16.54
Lodging	110	2,828	25.7	213	207	966	13.17
Mercantile and Service	792	8,520	10.8	395	385	1,979	11.50
Office	438	6.521	14.9	239	233	1,150	10.24
Public Assembly	189	2,662	14.1	142	138	675	14.12
Public Order and Safety	37	746	20.4	33	32	167	21.31
Religious Worship	159	2,001	12.5	57	56	303	13.93
Warehouse and Storage	173	4,595	26.5	106	103	559	13.64
Other	21	654	30.8	55	54	197	32.26
Vacant	61	658	10.8	26	26	119	37.29
Year Constructed							
1919 or Before	256	2,643	10.3	135	132	655	13.19
1920 to 1945	353	4,560	12.9	210	205	966	12.05
1946 to 1959	528	6,470	12.3	391	381	1,796	13.00
1960 to 1969	403	7,170	17.8	375	365	1,750	9.95
1970 to 1979	444	7,375	16.6	393	382	1,695	11.07
1980 to 1989	357	7,181	20.1	288	280	1,397	8.97
1990 to 1992	92	1,659	18.0	100	98	510	20.96
1993 to 1995	46	1,087	23.5	54	52	249	23.82
Census Region and Division							
Northeast	316	7,108	22.5	297	289	1,739	13.01
New England	34	1,433	42.6	74	72	432	26.89
Middle Atlantic	282	5,674	20.1	223	217	1,307	13.67
Midwest	777	10,905	14.0	750	730	2,947	8.96
East North Central	549	7,553	13.8	505	492	2,043	9.23
West North Central	228	3,352	14.7	244	238	903	17.01
South	805	12,291	15.3	528	514	2,560	9.33
South Atlantic	210	4,802	22.9	197	192	1,009	15.35
East South Central	248	3,163	12.8	164	160	792	19.83
West South Central	347	4,326	12.5	167	163	759	10.90
West	580	7,841	13.5	371	361	1,772	10.06
Mountain	219	2,624	12.0	150	146	585	17.21
Pacific	361	5,217	14.4	221	216	1,188	12.93
Climate Zone: 45-Year Average							
Fewer than 2,000 CDD and --							
More than 7,000 HDD	265	3,399	12.8	240	233	952	13.81
5,500-7,000 HDD	626	10,754	17.2	692	674	2,907	9.42
4,000-5,499 HDD	490	9,094	18.6	452	440	2,214	15.00
Fewer than 4,000 HDD	674	9,598	14.2	372	362	2,012	11.88
More than 2,000 CDD and --							
Fewer than 4,000 HDD	423	5,300	12.5	191	186	933	15.05

See footnotes at end of table.

Table C-14: Energy Consumption in Buildings (U.S. DOE, 1995).

Table 2. Energy End-Use Intensities for Sum of Major Fuels, 1995

Building Characteristics	Energy Intensity for Sum of Major Fuels (thousand Btu per sq. ft.)										RSE Row Factor
	Total	Space Heating	Cooling	Ventil-ation	Water Heating	Lighting	Cooking	Refrig-eration	Office Equip-ment	Other	
RSE Column Factor:	1.0	NF	NF	NF	NF	NF	NF	NF	NF	NF	
All Buildings	90.5	29.0	6.0	2.8	13.8	20.4	3.7	3.1	5.7	6.1	3.79
Building Floorspace (square feet)											
1,001 to 5,000	111.7	39.5	7.0	2.9	9.7	22.7	8.9	10.4	5.4	5.1	7.03
5,001 to 10,000	82.8	38.5	4.4	1.7	11.1	13.6	4.3	2.5	3.8	2.9	17.60
10,001 to 25,000	70.9	27.4	4.8	1.7	9.1	14.7	2.6	2.5	4.3	3.7	9.50
25,001 to 50,000	82.0	28.2	6.7	2.1	11.6	18.5	2.1	2.5	5.0	5.2	4.89
50,001 to 100,000	87.6	27.0	7.0	3.2	12.9	21.3	2.0	2.1	6.1	6.0	5.96
100,001 to 200,000	101.4	26.6	6.2	3.3	19.6	25.0	3.1	1.4	7.2	8.9	8.53
200,001 to 500,000	114.6	24.0	6.7	4.5	25.2	27.4	4.6	1.6	8.5	11.9	8.15
Over 500,000	96.8	18.5	6.0	3.9	18.0	28.6	3.5	2.2	7.0	9.1	12.38
Principal Building Activity											
Education	79.3	32.8	4.8	1.6	17.4	15.8	1.4	1.0	1.5	2.9	5.72
Food Sales	213.5	27.5	13.4	4.4	9.1	33.9	5.6	110.9	1.3	7.4	10.26
Food Service	245.5	30.9	19.5	5.3	27.5	37.0	77.5	31.6	2.6	13.7	13.47
Health Care	240.4	55.2	9.9	7.2	63.0	39.3	11.2	4.7	15.5	34.4	10.08
Lodging	127.3	22.7	8.1	1.7	51.4	23.2	6.6	2.3	3.8	7.5	7.33
Mercantile and Service	76.4	30.6	5.8	2.5	5.1	23.4	1.5	0.9	2.9	3.7	10.17
Office	97.2	24.3	9.1	5.2	8.7	28.1	1.1	0.4	15.1	5.2	6.03
Public Assembly	113.7	53.6	6.3	3.5	17.5	21.9	2.8	1.8	2.4	3.8	20.97
Public Order and Safety	97.2	27.8	6.1	2.3	23.4	16.4	Q	0.2	5.8	12.7	18.20
Religious Worship	37.4	23.7	1.9	0.9	3.2	5.0	0.5	0.6	0.4	1.1	12.45
Warehouse and Storage	38.3	15.7	0.9	0.3	2.0	9.8	(*)	1.7	4.4	3.4	8.57
Other	172.2	59.6	9.3	8.3	15.3	26.7	Q	0.7	15.2	35.9	15.83
Vacant	21.5	11.9	0.6	0.3	2.4	3.6	Q	0.2	0.5	1.9	28.33
Year Constructed											
1919 or Before	79.4	34.2	2.6	1.6	10.0	14.9	4.0	1.3	3.2	7.5	15.88
1920 to 1945	75.7	37.0	3.4	1.6	10.7	12.3	1.8	1.6	3.3	4.1	8.58
1946 to 1959	88.9	37.2	4.4	2.1	14.1	15.5	3.0	2.7	4.6	5.2	9.11
1960 to 1969	94.3	30.2	5.7	2.7	16.8	20.4	4.0	3.0	5.3	6.1	6.17
1970 to 1979	99.3	26.0	7.2	3.6	15.8	25.6	3.2	3.7	6.7	7.5	8.05
1980 to 1989	86.5	19.8	7.8	3.2	11.5	23.5	4.2	3.0	7.6	5.9	9.10
1990 to 1992	114.6	26.6	8.4	3.5	17.2	28.7	9.3	5.6	7.9	7.4	13.76
1993 to 1995	92.2	24.3	7.9	3.2	11.7	22.7	3.3	7.4	4.9	6.8	14.86
Floors											
One	75.2	26.0	5.6	2.1	7.9	17.0	4.3	4.6	4.1	3.7	7.30
Two	79.4	28.2	5.7	2.1	10.9	18.3	2.4	2.7	4.6	4.6	6.38
Three	92.0	34.8	5.1	2.3	15.0	18.6	2.8	1.4	5.2	6.7	6.72
Four to Nine	139.8	36.5	7.5	4.8	30.2	31.0	4.7	1.8	10.0	13.2	7.24
Ten or More	113.4	23.1	7.3	5.6	21.8	29.6	4.1	1.4	10.8	9.6	10.06
Census Region and Division											
Northeast	87.1	32.4	4.0	2.0	14.2	17.7	2.7	3.0	4.5	6.4	8.44
New England	87.3	37.7	3.3	1.6	15.2	16.0	1.9	1.9	4.1	5.5	10.89
Middle Atlantic	87.1	30.4	4.3	2.1	13.9	18.4	3.0	3.4	4.6	6.7	9.46
Midwest	104.5	46.7	4.3	2.5	15.6	18.8	3.5	2.4	5.1	5.6	7.54
East North Central	102.2	45.5	4.3	2.2	16.0	17.4	4.4	2.5	4.6	5.2	7.07
West North Central	109.3	49.1	4.3	3.0	14.8	21.8	1.8	2.1	6.1	6.3	17.03
South	80.8	18.0	8.4	3.2	10.5	21.3	4.0	3.4	5.9	6.0	5.47
South Atlantic	81.5	17.3	8.8	3.3	9.3	22.2	4.6	3.0	6.6	6.4	6.80
East South Central	84.8	24.4	7.5	2.7	11.7	21.2	2.2	3.7	5.3	6.2	15.33
West South Central	76.7	14.2	8.7	3.3	11.4	20.1	4.5	3.8	5.2	5.4	10.64
West	94.2	23.4	5.5	3.1	17.0	23.6	4.3	3.4	7.2	6.5	11.61
Mountain	111.3	40.8	5.9	3.3	21.4	21.7	2.8	3.2	6.8	5.4	21.62
Pacific	85.9	14.9	5.4	3.1	14.8	24.5	5.1	3.6	7.5	7.1	10.86

See footnotes at end of table.

APPENDIX D

Electrical, Cooling, and Heating Loads of the Building

Annual Loads

Table D-15: Annual Energy Use of the building.

Total Electric Energy (kWh)	Space Heating (kWh)	Cooling (kWh)	Ventilation (kWh)	Water heating (kWh)	Lighting (kWh)	Office equipment (kWh)
9.7E+01	2.4E+01	9.1E+00	5.2E+00	8.7E+00	2.8E+01	1.5E+01
2.8E+01	7.1E+00	2.7E+00	1.5E+00	2.5E+00	8.2E+00	4.4E+00
2.8E+06	7.1E+05	2.7E+05	1.5E+05	2.5E+05	8.2E+05	4.4E+05

Table D-16: Annual Energy Use of the Building (including chillers and boilers efficiencies).

Space & Water Heating (kWh)	8.2E+05
Cooling (kWh)	8.0E+05
Electric (kWh) (Ventilation+ Lighting+ Office Equipment)	1.4E+06
Electric (kWh) (Ventilation+ Lighting+ Office Equipment+ Cooling)	1.7E+06

Daily Loads

Table D-17: Daily Energy Use of the Building.

Month	Electrical Load (Equipment and Light) (kWh)	Heating Load (kWh)	Cooling Load (kWh)
January	4084	9044	-
May	3900	302	4454
August	3940	302	7077

Hourly Loads

Table D-18: Hourly Energy Use of the Building during a Typical Day in January.

Hour	Electrical Load (Equipment and Light) (kWh)	Heating Load (kWh)
1	90	411
2	86	396
3	83	386
4	79	390
5	77	408
6	74	425
7	90	428
8	188	550
9	269	394
10	269	353
11	269	348
12	269	306
13	269	263
14	269	228
15	269	236
16	269	290
17	269	339
18	221	407
19	173	461
20	111	356
21	103	390
22	94	414
23	98	428
24	95	438

Table D-19: Hourly Energy Use of the Building during a Typical Day in May.

Hour	Electrical Load (Equipment and light) (kWh)	Heating Load (kWh)	Cooling Load (kWh)
1	73	6	0
2	70	6	0
3	67	6	0
4	63	6	0
5	60	6	0
6	57	6	0
7	72	6	0
8	188	21	126
9	269	19	244
10	269	19	271
11	269	19	344
12	269	21	389
13	269	19	370
14	269	19	362
15	269	19	352
16	269	21	420
17	269	21	449
18	221	17	424
19	173	12	337
20	108	8	214
21	92	6	89
22	78	6	36
23	81	6	20
24	77	6	7

Table D-20: Hourly Energy Use of the Building during a Typical Day in August.

Hour	Electrical Load (Equipment and light) (kWh)	Heating Load (kWh)	Cooling Load (kWh)
1	77	6	80
2	73	6	68
3	70	6	65
4	67	6	66
5	63	6	69
6	60	6	66
7	76	6	83
8	188	21	234
9	269	19	294
10	269	19	395
11	269	19	371
12	269	21	460
13	269	19	597
14	269	19	623
15	269	19	579
16	269	21	714
17	269	21	699
18	221	17	563
19	173	12	367
20	110	8	280
21	94	6	146
22	81	6	98
23	84	6	83
24	80	6	77

APPENDIX E

Electrical Energy Production from Cogeneration Processes (TLF)

Table E-21: Annual Electric Production (TLF).

Cooling	**SOFC (kWh)**	**Microturbine (kWh)**	**3-MW ICE (kWh)**	**143-kW ICE (kWh)**
AC	7.8E+05	2.6E+06	1.5E+06	2.5E+06
EC	9.3E+05	3.1E+06	1.8E+06	2.9E+06

Table E-22: Daily Electric Production (TLF).

Month	**SOFC (kWh)**	**Microturbine (kWh)**	**3-MW ICE (kWh)**	**143-kW ICE (kWh)**
January	16350	4870	8603	5226
May	8213	2446	4322	2626
August	12730	3792	6698	4070

Table E-23: Electric Production during a Typical Day in January (TLF).

Hour	SOFC (kWh)	Microturbine (kWh)	3-MW ICE (kWh)	143-kW ICE (kWh)
1	743	221	391	237
2	717	213	377	229
3	697	208	367	223
4	704	210	371	225
5	738	220	388	236
6	767	229	404	245
7	774	230	407	247
8	994	296	523	318
9	712	212	375	228
10	638	190	336	204
11	629	187	331	201
12	553	165	291	177
13	476	142	250	152
14	412	123	217	132
15	426	127	224	136
16	524	156	276	167
17	614	183	323	196
18	735	219	387	235
19	833	248	439	266
20	644	192	339	206
21	705	210	371	225
22	749	223	394	239
23	775	231	408	248
24	791	236	416	253

Table E-24: Electric Production during a Typical Day in May (TLF).

Hour	SOFC (kWh)	Microturbine (kWh)	3-MW ICE (kWh)	143-kW ICE (kWh)
1	11	3	6	4
2	11	3	6	4
3	11	3	6	4
4	11	3	6	4
5	11	3	6	4
6	11	3	6	4
7	11	3	6	4
8	254	76	134	81
9	454	135	239	145
10	501	149	264	160
11	627	187	330	200
12	708	211	373	226
13	670	200	353	214
14	657	196	346	210
15	640	191	337	205
16	760	227	400	243
17	810	241	426	259
18	761	227	400	243
19	602	179	317	193
20	384	114	202	123
21	165	49	87	53
22	73	22	39	23
23	46	14	24	15
24	23	7	12	7

Table E-25: Electric Production during a Typical Day in August (TLF).

Hour	SOFC (kWh)	Microturbine (kWh)	3-MW ICE (kWh)	143-kW ICE (kWh)
1	149	44	78	48
2	128	38	67	41
3	124	37	65	40
4	125	37	66	40
5	130	39	69	42
6	126	37	66	40
7	154	46	81	49
8	440	131	232	141
9	540	161	284	173
10	715	213	376	228
11	673	200	354	215
12	830	247	437	265
13	1061	316	558	339
14	1107	330	582	354
15	1031	307	542	330
16	1267	377	667	405
17	1241	370	653	397
18	1000	298	526	320
19	655	195	345	209
20	496	148	261	159
21	262	78	138	84
22	179	53	94	57
23	154	46	81	49
24	144	43	76	46

APPENDIX F

Thermal Energy Production from Cogeneration Processes (ELF)

Table F-26: Annual Thermal Energy Production (ELF)

SOFC (kWh)	Microturbine (kWh)	3-MW ICE (kWh)	143-kW ICE (kWh)
2.8E+06	8.3E+05	1.5E+06	9.0E+05

Table F-27: Daily Thermal Energy Production (ELF)

Month	SOFC (kWh)	Microturbine (kWh)	3-MW ICE (kWh)	143-kW ICE (kWh)
January	2259	7585	4294	7067
May	3105	10425	5901	9713
August	3685	12372	7003	11527

Table F-28: Hourly Thermal Energy Production during a Typical Day in January (ELF).

Hour	SOFC (kWh)	Microturbine (kWh)	3-MW ICE (kWh)	143-kW ICE (kWh)
1	50	168	95	156
2	48	161	91	150
3	46	153	87	143
4	44	147	83	137
5	43	143	81	133
6	41	138	78	129
7	50	167	94	155
8	104	348	197	325
9	149	500	283	466
10	149	500	283	466
11	149	500	283	466
12	149	500	283	466
13	149	500	283	466
14	149	500	283	466
15	149	500	283	466
16	149	500	283	466
17	149	500	283	466
18	122	410	232	382
19	95	321	181	299
20	61	206	116	192
21	57	190	108	177
22	52	174	999	162
23	54	182	103	169
24	53	176	100	164

Table F-29: Hourly Thermal Production during a Typical Day in May (ELF).

Hour	SOFC (kWh)	Microturbine (kWh)	3-MW ICE (kWh)	143-kW ICE (kWh)
1	40	136	77	126
2	39	130	73	121
3	37	124	70	115
4	35	117	66	109
5	33	111	63	103
6	31	105	59	98
7	40	133	75	124
8	131	438	248	408
9	201	674	381	628
10	207	693	393	646
11	222	746	422	695
12	232	778	441	725
13	228	764	433	712
14	226	759	429	707
15	224	752	425	700
16	238	800	453	745
17	244	820	464	764
18	213	714	404	665
19	167	561	318	523
20	105	353	200	329
21	70	234	132	218
22	51	171	97	160
23	49	165	93	154
24	44	147	83	137

Table F-30: Hourly Thermal Production during a Typical Day in August (ELF).

Hour	SOFC (kWh)	Microturbine (kWh)	3-MW ICE (kWh)	143-kW ICE (kWh)
1	60	201	114	187
2	55	185	104	172
3	53	176	100	164
4	51	171	97	159
5	50	167	95	156
6	47	159	90	148
7	59	200	113	186
8	154	515	292	480
9	212	710	402	662
10	233	783	443	729
11	228	765	433	713
12	247	829	469	772
13	276	926	524	863
14	282	945	535	881
15	272	914	517	851
16	301	1010	572	941
17	298	999	566	931
18	242	813	460	757
19	174	583	330	543
20	120	404	229	376
21	83	278	157	259
22	66	220	125	205
23	64	215	122	200
24	61	204	116	190

APPENDIX G

GEMIS Input Data

Annual, Daily, & Hourly Scenarios Input Data

Table G-31: Annual Scenarios Input Data.

Scenarios	Options	Energy Source	Load (kWh)/Day	Key
First Scenario Baseline Case	Option (1)	NGCC	1.42E+06	Base Case NGCC
		Electric Chiller	8.0E+05	
		Gas Boiler	8.2E+05	
	Option (2)	Average Electric Generation Power Plant	1.42E+06	Base Case Electric
		Electric Chiller	8.0E+05	
		Gas Boiler	8.2E+05	
Second Scenario Thermal Load Following Case	Option (1)	SOFC Cogeneration	8.2E+05	SOFC-AC
		Absorption Chiller (run by SOFC)	8.0E+05	
	Option (2)	Microturbine Cogeneration	8.2E+05	Microturbine-AC
		Absorption Chiller (run by Microturbine)	8.0E+05	
		Average Electric Generation Power Plant	5.8E+05	
	Option (3)	3-MW ICE Cogeneration	8.2E+05	3-MW ICE-AC
		Absorption Chiller (run by ICE)	8.0E+05	

	Option (4)	**143-kW ICE Cogeneration**	**8.2E+05**	**143-kW ICE-AC**
		Absorption Chiller (run by ICE)	**8.0E+05**	
		Average Electric Generation Power Plant	**5.2E+05**	
Third Scenario Electrical Load Following Case	**Option (1)**	SOFC Cogeneration	1.6E+06	**SOFC-EC**
	Option (1) Part (II)	*SOFC Cogeneration*	1.4E+06	**SOFC-AC**
		SOFC Cogeneration (run to supply cooling demand)	8.0E+05	
		Gas Boiler (unmet heat)	3.7E+04	
	Option (2) Part (I)	**Microturbine Cogeneration**	1.6E+06	**Microturbin e-EC**
	Option (2) Part (II)	***Microturbine Cogeneration***	1.4E+06	**Microturbin e-AC**
	Option (3) Part (I)	3-MW ICE Cogeneration	1.6E+06	**3-MW ICE-EC**
	Option (3) Part (II)	*3-MW ICE Cogeneration*	1.6E+06	**3-MW ICE-AC**
		3-MW ICE Cogeneration (run to satisfy the unmet cooling demand)	1.9E+05	
	Option (4) Part (I)	**143-kW ICE Cogeneration**	1.6E+06	**143-kW ICE-EC**
	Option (4) Part(II)	***143-kW ICE Cogeneration*** *(run to satisfy the thermal demand unmet by the combination of absorption and electric chillers)*	1.4E+06	**143-kW ICE-AC**

Table G-32: Daily Input Data: January.

Scenarios	Options	Energy Source	Load (kWh)/Day	Key
First Scenario Baseline Case	Option (1)	NGCC	4084	Base Case NGCC
		Gas Boiler	9044	
	Option (2)	Average Electric Generation Power Plant	4084	Base Case Electric
		Gas Boiler	9044	
Second Scenario Thermal Load Following Case	Option (1)	SOFC Cogeneration	9044	SOFC
	Option (2)	Microturbine Cogeneration	9044	Microturbine
	Option (3)	3-MW ICE Cogeneration	9044	3-MW ICE
	Option (4)	143-kW ICE Cogeneration	9044	143-kW
Third Scenario Electrical Load Following Case	Option (1)	SOFC Cogeneration	4084	SOFC
		Gas Boiler	6176	
	Option (2)	Microturbine Cogeneration	4084	Microturbine
		Gas Boiler	1459	
	Option (3)	3-MW ICE Cogeneration	4084	3-MW ICE
		Gas Boiler	4750	
	Option (4)	143-kW ICE Cogeneration	4084	143-kW ICE
		Gas Boiler	1976	

Table G-33: Daily Input Data: May.

Scenarios	Options	Energy Source	Load (kWh)/Day	Key
First Scenario Baseline Case	**Option (1)**	NGCC	3900	**Base Case NGCC**
		Electric Chiller (ELF) or Absorption Chiller (TLF)	4454	
		Gas Boiler	302	
	Option (2)	**Average Electric Generation Power Plant**	**3900**	**Base Case Electric**
		Electric Chiller (ELF) or Absorption Chiller (TLF)	**4454**	
		Gas Boiler	**302**	
Second Scenario Thermal Load Following Case	**Option (1)**	SOFC Cogeneration	302	**SOFC**
		Absorption Chiller (run by SOFC)	4454	
	Option (2)	**Microturbine Cogeneration**	**302**	**Microturbine**
		Absorption Chiller (run by Microturbine)	**4454**	
		Average Electric Generation Power Plant	**1450**	
	Option (3)	3-MW ICE Cogeneration	302	**3-MW ICE**
		Absorption Chiller (run by ICE)	4544	
	Option (4)	**143-kW ICE Cogeneration**	**302**	**143-kW**
		Absorption Chiller (run by ICE)	**4544**	
		Average Electric Generation Power Plant	**1270**	
Third Scenario Electrical Load Following Case	**Option (1) Part (I)**	SOFC Cogeneration	3900	**SOFC-EC**
		Electric Chiller (run by SOFC)	4454	
	Option (1) Part (II)	*SOFC Cogeneration*	*3900*	**SOFC-AC/EC**
		SOFC Cogeneration (run to satisfy the thermal demand unmet by the combination of absorption and electric chillers)	*472*	

	Option (2) Part (I)	**Microturbine Cogeneration**	**3900**	**Microturbine-EC**
		Electric Chiller (run by Microturbine)	**4454**	
	Option (2) Part (II)	***Microturbine Cogeneration*** *(run to satisfy the thermal demand unmet by the combination of absorption and electric chillers)*	***3900***	**Microturbine-AC/EC**
	Option (3) Part (I)	3-MW ICE Cogeneration	3900	**3-MW ICE-EC**
		Electric Chiller (run by ICE)	4454	
	Option (3) Part (II)	*3-MW ICE Cogeneration*	*3900*	**3-MW ICE-AC/EC**
		3-MW ICE Cogeneration (run to satisfy the thermal demand unmet by the combination of absorption and electric chillers)	*49*	
	Option (4) Part (I)	**143-kW ICE Cogeneration**	**3900**	**143-kW ICE-EC**
		Electric Chiller (run by ICE)	**4454**	
	Option (4) Part(II)	***143-kW ICE Cogeneration*** *(run to satisfy the thermal demand unmet by the combination of absorption and electric chillers)*	***3900***	**143-kW ICE-AC/EC**

Table G-34: Daily Input Data: August.

Scenarios	Options	Energy Source	Load (kWh)/Day	Key
First Scenario Baseline Case	**Option (1)**	NGCC	3940	**Base Case NGCC**
		Electric Chiller (ELF) or Absorption Chiller (TLF)	7077	
		Gas Boiler	302	
	Option (2)	**Average Electric Generation Power Plant**	**3940**	**Base Case Electric**
		Electric Chiller (ELF) or Absorption Chiller (TLF)	**7077**	
		Gas Boiler	**302**	
Second Scenario Thermal Load Following Case	**Option (1)**	SOFC Cogeneration	302	**SOFC**
		Absorption Chiller (run by SOFC)	7077	
	Option (2)	**Microturbine Cogeneration**	**302**	**Microturbine**
		Absorption Chiller (run by Microturbine)	**7077**	
		Average Electric Generation Power Plant	**148**	
	Option (3)	3-MW ICE Cogeneration	302	**3-MW ICE**
		Absorption Chiller (run by ICE)	7077	
	Option (4)	**143-kW ICE Cogeneration**	**302**	**143-kW**
		Absorption Chiller (run by ICE)	**7077**	
Third Scenario Electrical Load Following Case	**Option (1) Part (I)**	SOFC Cogeneration	3940	**SOFC-EC**
		Electric Chiller (run by SOFC)	7077	
	Option (1) Part (II)	*SOFC Cogeneration*	*3940*	**SOFC-AC/EC**
		SOFC Cogeneration (run to satisfy the thermal demand unmet by the combination of absorption and electric chillers)	*981*	
	Option (2) Part (I)	**Microturbine Cogeneration**	**3940**	**Microturbine-EC**

		Electric Chiller (run by Microturbine)	**7077**	
	Option (2) Part (II)	***Microturbine Cogeneration*** *(run to satisfy the thermal demand unmet by the combination of absorption and electric chillers)*	***3940***	**Microturbine-AC/EC**
	Option (3) Part (I)	3-MW ICE Cogeneration	3940	**3-MW ICE-EC**
		Electric Chiller (run by ICE)	7077	
	Option (3) Part (II)	*3-MW ICE Cogeneration*	*3940*	**3-MW ICE-AC/EC**
		3-MW ICE Cogeneration (run to satisfy the thermal demand unmet by the combination of absorption and electric chillers)	*504*	
	Option (4) Part (I)	**143-kW ICE Cogeneration**	**3940**	**143-kW ICE-EC**
		Electric Chiller (run by ICE)	**7077**	
	Option (4) Part(II)	***143-kW ICE Cogeneration*** *(run to satisfy the thermal demand unmet by the combination of absorption and electric chillers)*	***3940***	**143-kW ICE-AC/EC**

Table G-35: Hourly- Input Data: Typical Day in January.

January								
Scenarios	Second Scenario Thermal Load Following Case				First Scenario Base Line Case			
Options	Option (3)	Option (2)		Option (1)	Option (2)		Option (1)	
Energy Source	3-MW ICE	Average El ti	Microturbine	SOFC	Gas Boiler	Average	Gas Boiler	NGCC
Load (kWh)/hour								
Hour 3	386	0	386	386	386	83	386	83
Hour 4	390	0	390	390	390	79	390	79
Hour 5	408	0	408	408	408	77	408	77
Hour 6	425	0	425	425	425	74	425	74
Hour 7	428	0	428	428	428	90	428	90
Hour 8	550	0	550	550	550	188	550	188
Hour 9	394	57.3	394	394	394	269	394	269
Hour 10	353	79.4	353	353	353	269	353	269
Hour 11	348	82	348	348	348	269	348	269
Hour 12	306	105	306	306	306	269	306	269
Hour 13	362	128	362	362	362	269	362	269
Hour 14	228	147	228	228	228	269	228	269
Hour 15	236	142	236	236	236	269	236	269
Hour 16	290	113	290	290	290	269	290	269
Hour 17	339	86.6	339	339	339	269	339	269
Hour 18	407	2.07	407	407	407	221	407	221
Hour 19	461	0	461	461	461	173	461	173
Hour 20	356	0	356	356	356	111	356	111
Hour 21	390	0	390	390	390	103	390	103
Hour 22	414	0	414	414	414	94	414	94

Third Scenario
Electrical Load Following Case

Option (4)	Option (3)		Option (2)		Option (1)		Option (4)		
143-kW ICE	Gas Boiler	3-MW ICE	Gas Boiler	Microturbine	Gas Boiler	SOFC	Average	143-kW ICE	Average El t i
83	299	83	232	83	340	83	0	386	0
79	306	79	242	79	346	79	0	390	0
77	327	77	265	77	365	77	0	408	0
74	346	74	286	74	383	74	0	425	0
90	334	90	261	90	378	90	0	428	0
188	353	188	202	188	446	188	0	550	0
269	111	269	0	269	245	269	41.7	394	0
269	70	269	0	269	204	269	65.4	353	0
269	65	269	0	269	199	269	68.3	348	0
269	23	269	0	269	157	269	92.7	306	0
269	0	269	0	269	114	269	117	362	18.9
269	0	269	0	269	79	269	138	228	52.4
269	0	269	0	269	87	269	133	236	45
269	7	269	0	269	141	269	102	290	0
269	56	269	0	269	190	269	73.2	339	0
221	174	221	0	221	284	221	0	407	0
173	280	173	140	173	365	173	0	461	0
111	239	111	150	111	295	111	0	356	0
103	282	103	199	103	333	103	0	390	0
94	316	94	240	94	362	94	0	414	0

Gas Boiler
243
252
275
296
273
225
0
0
0
0
0
0
0
0
0
24
162
164
212
252

Table G-36: Hourly Input Data: Typical Day in May.

May								
Scenarios	Second Scenario Thermal Load Following		First Scenario Base Line Case					
Options	Option (1)		Option (2)			Option (1)		
Energy Source	Absorption	SOFC	Absorption or Gas Boiler	Gas Boiler	Average	Absorption	Gas Boiler	NGCC
Load (kWh)/hour								
Hour 3	0	6	0	6	67	0	6	67
Hour 4	0	6	0	6	63	0	6	63
Hour 5	0	6	0	6	60	0	6	60
Hour 6	0	6	0	6	57	0	6	57
Hour 7	0	6	0	6	72	0	6	72
Hour 8	126	21	126	21	188	126	21	188
Hour 9	244	19	244	19	269	244	19	269
Hour 10	271	19	271	19	269	271	19	269
Hour 11	344	19	344	19	269	344	19	269
Hour 12	389	21	389	21	269	389	21	269
Hour 13	370	19	370	19	269	370	19	269
Hour 14	362	19	362	19	269	362	19	269
Hour 15	352	19	352	19	269	352	19	269
Hour 16	420	21	420	21	269	420	21	269
Hour 17	449	21	449	21	269	449	21	269
Hour 18	424	17	424	17	221	424	17	221
Hour 19	337	12	337	12	173	337	12	173
Hour 20	214	8	214	8	108	214	8	108
Hour 21	89	6	89	6	92	89	6	92
Hour 22	36	6	36	6	78	36	6	78

Option (4)			Option (3)			Option (2)			
Average	Absorption	143-kW ICE	**Average**	**Absorption**	**3-MW ICE**	Average	Absorption	Microturbine	**Average**
62.9	0	6	**60.6**	**0**	**6**	63.2	0	6	**55.3**
59.4	0	6	**57.1**	**0**	**6**	59.7	0	6	**51.7**
56.2	0	6	**53.9**	**0**	**6**	56.4	0	6	**48.5**
53	0	6	**50.6**	**0**	**6**	53.2	0	6	**45.3**
67.9	0	6	**65.6**	**0**	**6**	68.2	0	6	**60.2**
106	126	21	**53.9**	**126**	**21**	112	126	21	**0**
124	244	19	**30.3**	**244**	**19**	134	244	19	**0**
109	271	19	**5.5**	**271**	**19**	120	271	19	**0**
69	344	19	**0**	**344**	**19**	82.6	344	19	**0**
43	389	21	**0**	**389**	**21**	58.5	389	21	**0**
55.1	370	19	**0**	**370**	**19**	69.7	370	19	**0**
59.3	362	19	**0**	**362**	**19**	73.6	362	19	**0**
64.8	352	19	**0**	**352**	**19**	78.7	352	19	**0**
25.9	420	21	**0**	**420**	**21**	42.5	420	21	**0**
10	449	21	**0**	**449**	**21**	27.7	449	21	**0**
0	424	17	**0**	**424**	**17**	0	424	17	**0**
0	337	12	**0**	**337**	**12**	0	337	12	**0**
0	214	8	**0**	**214**	**8**	0	214	8	**0**
39.1	89	6	**5.03**	**89**	**6**	42.7	89	6	**0**
55	36	6	**39.9**	**36**	**6**	56.6	36	6	**5.13**

Third Scenario
Electrical Load Following Case

Option 2 Part	**Option (2) Part (I)**			**Option 1 Part**	**Option (1) Part (I)**	
Microturbine	Electric	Microturbine	**SOFC (run to satisfy the**	**SOFC**	**Electric Chiller**	**SOFC**
67	0	67	**0**	**67**	**0**	**67**
63	0	63	**0**	**63**	**0**	**63**
60	0	60	**0**	**60**	**0**	**60**
57	0	57	**0**	**57**	**0**	**57**
72	0	72	**0**	**72**	**0**	**72**
188	126	188	**7**	**188**	**126**	**188**
269	244	269	**20**	**269**	**244**	**269**
269	271	269	**25**	**269**	**271**	**269**
269	344	269	**39**	**269**	**344**	**269**
269	389	269	**49**	**269**	**389**	**269**
269	370	269	**44**	**269**	**370**	**269**
269	362	269	**43**	**269**	**362**	**269**
269	352	269	**41**	**269**	**352**	**269**
269	420	269	**55**	**269**	**420**	**269**
269	449	269	**60**	**269**	**449**	**269**
221	424	221	**60**	**221**	**424**	**221**
173	337	173	**48**	**173**	**337**	**173**
108	214	108	**31**	**108**	**214**	**108**
92	89	92	**8**	**92**	**89**	**92**
78	36	78	**0**	**78**	**36**	**78**

Option (4)	Option (4) Part (I)		Option (3) Part (II)		Option (3) Part (I)		
143-kW ICE	Electric	143-kW ICE	**3-MW ICE (run to satisfy**	**3-MW ICE**	**Electric Chiller**	**3-MW ICE**	Microturbine (run to satisfy
67	0	67	**0**	**67**	**0**	**67**	0
63	0	63	**0**	**63**	**0**	**63**	0
60	0	60	**0**	**60**	**0**	**60**	0
57	0	57	**0**	**57**	**0**	**57**	0
72	0	72	**0**	**72**	**0**	**72**	0
188	126	188	**0.47**	**188**	**126**	**188**	0
269	244	269	**12**	**269**	**244**	**269**	0
269	271	269	**18**	**269**	**271**	**269**	0
269	344	269	**33**	**269**	**344**	**269**	0
269	389	269	**43**	**269**	**389**	**269**	0
269	370	269	**38**	**269**	**370**	**269**	0
269	362	269	**37**	**269**	**362**	**269**	0
269	352	269	**35**	**269**	**352**	**269**	0
269	420	269	**49**	**269**	**420**	**269**	0
269	449	269	**55**	**269**	**449**	**269**	0
221	424	221	**57**	**221**	**424**	**221**	0
173	337	173	**45**	**173**	**337**	**173**	0
108	214	108	**29**	**108**	**214**	**108**	0.45
92	89	92	**5**	**92**	**89**	**92**	0
78	36	78	**0**	**78**	**36**	**78**	0

143-kW ICE (run to satisfy
0
0
0
0
0
0
0
0
6
15
11
10
8
22
27
33
27
18
0
0

Table G-37: Hourly Input Data: Typical Day in August.

August								
Scenarios	First Scenario Base Line Case						Second Scenario Thermal Load Following	
Options	Option (1)			Option (2)			Option (1)	
Energy Source	NGCC	Gas Boiler	Absorption or Electric	Average Electric	Gas Boiler	Absorption or Electric	SOFC	Absorption Chiller (run
Load (kWh)/hour								
Hour 3	70	6	65	70	6	65	6	65
Hour 4	67	6	66	67	6	66	6	66
Hour 5	63	6	69	63	6	69	6	69
Hour 6	60	6	66	60	6	66	6	66
Hour 7	76	6	83	76	6	83	6	83
Hour 8	188	21	234	188	21	234	21	234
Hour 9	269	19	294	269	19	294	19	294
Hour 10	269	19	395	269	19	395	19	395
Hour 11	269	19	371	269	19	371	19	371
Hour 12	269	21	460	269	21	460	21	460
Hour 13	269	19	597	269	19	597	19	597
Hour 14	269	19	623	269	19	623	19	623
Hour 15	269	19	579	269	19	579	19	579
Hour 16	269	21	714	269	21	714	21	714
Hour 17	269	21	699	269	21	699	21	699
Hour 18	221	17	563	221	17	563	17	563
Hour 19	173	12	367	173	12	367	12	367
Hour 20	110	8	280	110	8	280	8	280
Hour 21	94	6	146	94	6	146	6	146
Hour 22	81	6	98	81	6	98	6	98

Third Scenario									
Option (1) Part (I)	**Option (4)**			**Option (3)**			**Option (2)**		
SOFC	Average Electric	Absorption Chiller (run	143-kW ICE	**Average Electric**	**Absorption Chiller (run**	**3-MW ICE**	Average Electric	Absorption Chiller (run by	Microturbine
70	30.2	65	6	**4.65**	**65**	**6**	32.9	65	6
67	26.4	66	6	**0.54**	**66**	**6**	29.2	66	6
63	21.7	69	6	**0**	**69**	**6**	24.5	69	6
60	19.8	66	6	**0**	**66**	**6**	22.6	66	6
76	46.8	83	6	**0**	**83**	**6**	29.7	83	6
188	96.9	234	21	**0**	**234**	**21**	56.4	234	21
269	40.9	294	19	**0**	**294**	**19**	108	294	19
269	54.3	395	19	**0**	**395**	**19**	56.5	395	19
269	4	371	19	**0**	**371**	**19**	69	371	19
269	0	460	21	**0**	**460**	**21**	22.1	460	21
269	0	597	19	**0**	**597**	**19**	0	597	19
269	0	623	19	**0**	**623**	**19**	0	623	19
269	0	579	19	**0**	**579**	**19**	0	579	19
269	0	714	21	**0**	**714**	**21**	0	714	21
269	0	699	21	**0**	**699**	**21**	0	699	21
221	0	563	17	**0**	**563**	**17**	0	563	17
173	0	367	12	**0**	**367**	**12**	0	367	12
110	0	280	8	**0**	**280**	**8**	0	280	8
94	10.1	146	6	**0**	**146**	**6**	15.8	146	6
81	23.9	98	6	**0**	**98**	**6**	27.8	98	6

Option (3) Part (I)	Option 2 Part (II)		Option (2) Part (I)			Option 1 Part (II)	
3-MW ICE	Microturbine (run to satisfy the thermal demand unmet	Microturbine	Electric Chiller (run by	Microturbine	**SOFC (run to satisfy the thermal demand unmet by the**	SOFC	**Electric Chiller (run by SOFC)**
70	0	70	0	70	**6**	**70**	65
67	0	67	0	67	**6**	**67**	66
63	0	63	0	63	**7**	**63**	69
60	0	60	0	60	**7**	**60**	66
76	0	76	0	76	**9**	**76**	83
188	0	188	126	188	**28**	**188**	234
269	0	269	244	269	**30**	**269**	294
269	0	269	271	269	**49**	**269**	395
269	0	269	344	269	**45**	**269**	371
269	0	269	389	269	**62**	**269**	460
269	10	269	370	269	**89**	**269**	597
269	14	269	362	269	**94**	**269**	623
269	8	269	352	269	**85**	**269**	579
269	29	269	420	269	**112**	**269**	714
269	26	269	449	269	**109**	**269**	699
221	20	221	424	221	**87**	**221**	563
173	4	173	337	173	**54**	**173**	367
110	10	110	214	110	**43**	**110**	280
94	0	94	89	94	**19**	**94**	146
81	0	81	36	81	**11**	**81**	98

Option (4) Part (II)		Option (4) Part (I)		Option (3) Part (II)		
143-kW ICE (run to satisfy the thermal demand unmet	143-kW ICE	Electric Chiller (run	143-kW ICE	**3-MW ICE (run to satisfy the thermal demand**	**3-MW ICE**	**Electric Chiller (run by ICE)**
0	**70**	0	**70**	**4**	**70**	**0**
0	**67**	0	**67**	**4**	**67**	**0**
0	**63**	0	**63**	**6**	**63**	**0**
0	**60**	0	**60**	**6**	**60**	**0**
0	**76**	0	**76**	**7**	**76**	**0**
4	**188**	126	**188**	**23**	**188**	**126**
0	**269**	244	**269**	**23**	**269**	**244**
16	**269**	271	**269**	**44**	**269**	**271**
11	**269**	344	**269**	**38**	**269**	**344**
29	**269**	389	**269**	**57**	**269**	**389**
56	**269**	370	**269**	**85**	**269**	**370**
61	**269**	362	**269**	**91**	**269**	**362**
53	**269**	352	**269**	**82**	**269**	**352**
80	**269**	420	**269**	**110**	**269**	**420**
77	**269**	449	**269**	**107**	**269**	**449**
61	**221**	424	**221**	**85**	**221**	**424**
33	**173**	337	**173**	**52**	**173**	**337**
30	**110**	214	**110**	**42**	**110**	**214**
7	**94**	89	**94**	**17**	**94**	**89**
1	**81**	36	**81**	**9**	**81**	**36**

APPENDIX H

GEMIS Output Data

Air Emissions, Energy Consumption, Liquid Effluents, & Residuals

Annual Data

Table H-38: Annual Air Emissions.

Option [kg]	NGCC-EC	Electric-EC	143-kW ICE-	3-MW ICE-	Micro-AC(ELF)	SOFC-AC(ELF)
TOPP	2.6E+03	5.6E+03	2.2E+03	1.9E+03	8.2E+02	7.1E+02
SO2 eq.	1.5E+03	4.2E+03	8.0E+02	6.8E+02	4.6E+02	4.0E+02
SO2	8.8E+01	1.2E+03	8.1E+01	7.0E+01	8.8E+01	7.4E+01
NOx	2.0E+03	4.1E+03	1.0E+03	8.7E+02	5.3E+02	4.7E+02
HCl	2.4E+00	9.2E+01	2.7E+00	2.3E+00	2.8E+00	3.0E+00
HF	2.5E-01	4.6E+00	2.7E-01	2.4E-01	2.9E-01	3.0E-01
Particulat	6.0E+01	1.6E+02	8.6E+01	7.3E+01	1.5E+01	2.8E+01
CO	6.9E+02	1.1E+03	7.1E+03	6.0E+03	1.0E+03	3.2E+02
NMVOC	4.2E+01	4.1E+02	9.7E+01	8.2E+01	1.6E+01	4.8E+01
H2S	4.6E-03	1.1E-03	5.1E-03	4.3E-03	5.3E-03	1.2E-02
NH3	2.2E-04	3.9E-02	2.2E-04	2.3E-04	2.3E-04	4.8E-04
Acetalde	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	2.8E-04	2.8E-04	0.0E+00	0.0E+00	0.0E+00	1.3E-05
Barium	6.4E-03	6.4E-03	0.0E+00	0.0E+00	0.0E+00	2.9E-04
Benzene	1.1E-01	0.0E+00	2.2E+03	2.5E+03	0.0E+00	0.0E+00
Berylliu	1.7E-05	1.7E-05	0.0E+00	0.0E+00	0.0E+00	7.7E-07
Cadmiu	1.5E-03	1.5E-03	0.0E+00	0.0E+00	0.0E+00	7.0E-05
Chromiu	2.0E-03	2.0E-03	0.0E+00	0.0E+00	0.0E+00	8.9E-05
Cobalt	1.2E-04	1.2E-04	0.0E+00	0.0E+00	0.0E+00	5.4E-06
Copper	1.2E-03	1.2E-03	0.0E+00	0.0E+00	0.0E+00	5.4E-05
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.1E+02	0.0E+00
Lead	7.0E-04	7.0E-04	0.0E+00	0.0E+00	0.0E+00	3.2E-05
Mangane	5.4E-04	5.4E-04	0.0E+00	0.0E+00	0.0E+00	2.4E-05
Mercury	3.7E-04	3.7E-04	0.0E+00	0.0E+00	0.0E+00	1.7E-05
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybde	1.5E-03	1.5E-03	0.0E+00	0.0E+00	0.0E+00	7.0E-05
Nickel	3.0E-03	3.0E-03	0.0E+00	0.0E+00	0.0E+00	1.3E-04
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Selenium	3.4E-05	3.4E-05	0.0E+00	0.0E+00	0.0E+00	1.5E-06
TOC	1.5E+01	1.5E+01	8.9E+00	1.0E+01	0.0E+00	7.0E-01
Toluene	0.0E+00	0.0E+00	3.1E+00	3.5E+00	0.0E+00	0.0E+00
Vanadiu	3.3E-03	3.3E-03	0.0E+00	0.0E+00	0.0E+00	1.5E-04
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	7.7E+00	7.7E+00	0.0E+00	0.0E+00	0.0E+00	3.5E-01
Xylene	0.0E+00	0.0E+00	1.1E+00	1.2E+00	0.0E+00	0.0E+00
Zinc	4.1E-02	4.1E-02	0.0E+00	0.0E+00	0.0E+00	1.9E-03

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.8E-02	7.8E-02
0.0E+00	0.0E+00	1.3E+00	1.3E+00	1.2E+00	0.0E+00	0.0E+00	1.2E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E+01	1.5E+01
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.3E-03	6.3E-03
0.0E+00	0.0E+00	3.7E+00	3.7E+00	3.5E+00	0.0E+00	0.0E+00	3.5E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	1.1E+01	1.1E+01	9.9E+00	0.0E+00	0.0E+00	9.9E+00	0.0E+00	3.0E+01	3.0E+01
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.5E-05	6.5E-05
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.7E-03	5.7E-03
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-03	3.0E-03
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.1E-04	7.1E-04
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-03	1.0E-03
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-03	1.4E-03
0.0E+00	1.3E+02	0.0E+00	0.0E+00	0.0E+00	1.2E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-03	2.3E-03
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-04	2.3E-04
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.8E-03	3.8E-03
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-03	3.0E-03
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.3E-05	3.3E-05
0.0E+00	0.0E+00	2.6E+03	2.6E+03	2.5E+03	0.0E+00	0.0E+00	2.5E+03	0.0E+00	1.0E-01	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.2E-02	1.2E-02
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.4E-04	5.4E-04
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
1.6E-04	2.7E-04	2.1E-04	2.6E-04	3.2E-04	1.5E-02	5.7E-04	1.3E-02	5.1E-03	3.7E-04	3.5E-02
3.8E-03	6.3E-03	4.6E-03	6.1E-03	4.1E-03	3.2E-03	1.7E-02	3.3E-03	8.9E-03	5.1E-03	2.0E-03
1.4E+01	1.9E+01	8.7E+01	1.2E+02	7.9E+01	1.6E+02	7.2E+01	1.9E+02	8.6E+01	5.9E+01	3.9E+02
1.2E+02	1.2E+03	6.4E+03	8.4E+03	5.7E+03	9.8E+02	4.5E+02	4.9E+03	3.6E+02	7.6E+02	1.2E+03
1.2E+01	1.8E+01	7.7E+01	1.0E+02	6.9E+01	6.5E+01	3.5E+01	1.1E+02	3.7E+01	6.7E+01	1.6E+02
2.4E-01	3.4E-01	2.5E-01	3.3E-01	2.3E-01	1.9E+00	1.8E-01	1.7E+00	6.6E-01	2.9E-01	4.2E+00
2.1E+00	3.3E+00	2.4E+00	3.2E+00	2.5E+00	3.6E+01	2.2E+00	3.2E+01	1.2E+01	3.0E+00	8.3E+01
1.5E+02	6.2E+02	9.2E+02	1.2E+03	8.4E+02	1.8E+03	6.9E+02	2.0E+03	8.6E+02	1.9E+03	3.8E+03
5.9E+01	1.0E+02	7.3E+01	9.6E+01	6.9E+01	5.1E+02	4.5E+01	4.6E+02	1.8E+02	9.8E+01	1.1E+03
1.7E+02	5.4E+02	7.1E+02	9.5E+02	6.5E+02	1.8E+03	5.3E+02	1.9E+03	7.8E+02	1.4E+03	3.9E+03
2.5E+02	9.8E+02	2.0E+03	2.6E+03	1.8E+03	2.5E+03	1.0E+03	3.2E+03	1.2E+03	2.5E+03	5.3E+03
SOFC-EC(ELF)	Microtur bine-	3-MW ICE-	143 kW ICE-	3-MW ICE	Micro-AC(TLF)	SOFC-AC(TLF)	143-kW ICE	SOFC-EC(TLF)	NGCC-AC	Electric-AC

Table H-39: Annual GWP Emissions.

Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethane	4.1E-06	5.6E-04	4.3E-06	4.4E-06	4.5E-06	2.2E-03	1.7E-03	5.3E-06	4.1E-06	5.2E-06
Perfluoromethane	3.3E-05	4.5E-03	3.5E-05	3.5E-05	3.6E-05	1.7E-02	1.3E-02	4.3E-05	3.3E-05	4.1E-05
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.9E+01	6.5E+01	3.0E+01	2.5E+01	2.3E+00	4.3E+00	1.7E+00	2.7E+00	2.6E+01	3.5E+01
CH4	3.6E+03	3.6E+03	4.6E+03	3.9E+03	4.1E+03	4.2E+03	2.9E+03	4.9E+03	4.1E+03	5.5E+03
CO2	8.1E+05	1.4E+06	8.7E+05	7.3E+05	1.1E+06	1.3E+06	7.4E+05	1.3E+06	7.8E+05	1.0E+06
CO2 eq.	9.0E+05	1.5E+06	9.7E+05	8.2E+05	1.2E+06	1.4E+06	8.0E+05	1.4E+06	8.7E+05	1.2E+06
Option [kg]	NGCC-EC	Electric-EC	143-kW ICE-AC (ELF)	3-MW ICE-AC (ELF)	Microturbine-AC (ELF)	SOFC-AC (ELF)	SOFC-EC (ELF)	Microturbine-EC (ELF)	3-MW ICE-EC (ELF)	143-kW ICE-EC (ELF)

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.7E-06	2.1E-04	1.6E-03	9.0E-04	1.9E-04	6.4E-06	5.1E-04
4.5E-05	1.7E-03	1.3E-02	7.2E-03	1.5E-03	5.1E-05	4.0E-03
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.4E+01	2.5E+01	5.6E+00	1.1E+01	4.0E+01	1.9E+01	6.0E+01
3.7E+03	3.6E+03	3.5E+03	2.2E+03	4.0E+03	4.0E+03	4.1E+03
7.0E+05	1.1E+06	1.3E+06	8.4E+05	9.5E+05	9.3E+05	1.4E+06
7.8E+05	1.2E+06	1.4E+06	8.9E+05	1.0E+06	1.0E+06	1.5E+06
3-MW ICE-AC (TLF)	Microtur bine-AC (TLF)	SOFC-AC (TLF)	SOFC-EC (TLF)	143-kW ICE-AC (TLF)	NGCC-AC	Electric-AC

Table H-40: Annual Primary Energy Consumption.

Option [kWh]	Sum	non renewable	renewable	other
Base Case NGCC-EC	4.80E+06	4.80E+06	2.13E+03	1.75E+03
Base Case Electric-EC	5.90E+06	5.43E+06	1.56E+05	3.14E+05
143-kW ICE-AC	5.29E+06	5.29E+06	2.34E+03	1.87E+03
3-MW ICE-AC	4.48E+06	4.47E+06	2.11E+03	2.01E+03
Microturbine-AC	5.54E+06	5.54E+06	2.45E+03	1.92E+03
SOFC-AC	6.67E+06	6.66E+06	3.87E+03	5.59E+03
SOFC-EC	3.92E+06	3.92E+06	1.90E+03	1.39E+03
Microturbine-EC	6.58E+06	6.58E+06	2.91E+03	2.29E+03
3-MW ICE-EC	4.73E+06	4.72E+06	2.10E+03	1.85E+03
143-kW ICE-EC	6.29E+06	6.29E+06	2.78E+03	2.22E+03
3-MW ICE-AC	4.25E+06	4.24E+06	2.40E+03	2.75E+03
Microturbine-AC	5.16E+06	4.98E+06	5.93E+04	1.18E+05
SOFC-AC	6.90E+06	6.89E+06	4.12E+03	7.98E+03
143-kW ICE-AC	5.05E+06	4.89E+06	5.33E+04	1.06E+05
SOFC-EC	4.19E+06	4.12E+06	2.14E+04	4.30E+04
Base Case NGCC-AC	5.35E+06	5.34E+06	2.89E+03	2.97E+03
Base Case Average-AC	6.35E+06	5.93E+06	1.41E+05	2.83E+05

Hourly Data

Table H-41: Hourly Air Emissions from NGCC in January.

Option	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
TOPP eq.	2.08E-01	2.03E-01	2.04E-01	2.03E-01	2.28E-01	4.02E-01	4.89E-01	4.80E-01	4.79E-01	4.70E-01
SO2 eq.	1.14E-01	1.11E-01	1.12E-01	1.11E-01	1.25E-01	2.23E-01	2.75E-01	2.70E-01	2.70E-01	2.65E-01
SO2	1.10E-02	1.09E-02	1.11E-02	1.13E-02	1.21E-02	1.88E-02	1.96E-02	1.88E-02	1.87E-02	1.79E-02
NOx	1.48E-01	1.44E-01	1.44E-01	1.43E-01	1.62E-01	2.92E-01	3.66E-01	3.61E-01	3.60E-01	3.54E-01
HCl	3.43E-04	3.40E-04	3.49E-04	3.56E-04	3.78E-04	5.73E-04	5.73E-04	5.47E-04	5.44E-04	5.18E-04
HF	3.50E-05	3.47E-05	3.56E-05	3.64E-05	3.85E-05	5.85E-05	5.86E-05	5.60E-05	5.57E-05	5.30E-05
Particulat	8.71E-03	8.66E-03	8.90E-03	9.09E-03	9.60E-03	1.44E-02	1.42E-02	1.36E-02	1.35E-02	1.28E-02
CO	9.58E-02	9.51E-02	9.76E-02	9.96E-02	1.06E-01	1.60E-01	1.60E-01	1.53E-01	1.52E-01	1.45E-01
NMVOC	1.04E-02	1.04E-02	1.08E-02	1.12E-02	1.15E-02	1.57E-02	1.31E-02	1.22E-02	1.20E-02	1.10E-02
H2S	6.49E-07	6.45E-07	6.62E-07	6.75E-07	7.15E-07	1.09E-06	1.09E-06	1.04E-06	1.03E-06	9.81E-07
NH3	2.83E-08	2.80E-08	2.87E-08	2.91E-08	3.11E-08	4.81E-08	4.96E-08	4.76E-08	4.73E-08	4.53E-08
Acetalde	0	0	0	0	0	0	0	0	0	0
Acrolein	0	0	0	0	0	0	0	0	0	0
arsenic	1.32E-07	1.33E-07	1.39E-07	1.45E-07	1.46E-07	1.88E-07	1.35E-07	1.21E-07	1.19E-07	1.05E-07
Barium	2.98E-06	3.01E-06	3.15E-06	3.28E-06	3.31E-06	4.25E-06	3.04E-06	2.73E-06	2.69E-06	2.36E-06
Benzene	5.87E-06	5.59E-06	5.44E-06	5.23E-06	6.36E-06	1.33E-05	1.90E-05	1.90E-05	1.90E-05	1.90E-05
Beryllu	7.94E-09	8.03E-09	8.40E-09	8.75E-09	8.81E-09	1.13E-08	8.11E-09	7.26E-09	7.16E-09	6.30E-09
Cadmiu	7.27E-07	7.35E-07	7.68E-07	8.01E-07	8.06E-07	1.04E-06	7.42E-07	6.65E-07	6.55E-07	5.76E-07
Chromiu	9.22E-07	9.32E-07	9.75E-07	1.02E-06	1.02E-06	1.31E-06	9.42E-07	8.44E-07	8.32E-07	7.31E-07
Cobalt	5.55E-08	5.60E-08	5.86E-08	6.11E-08	6.15E-08	7.90E-08	5.66E-08	5.07E-08	5.00E-08	4.40E-08
Copper	5.61E-07	5.67E-07	5.93E-07	6.17E-07	6.22E-07	7.99E-07	5.72E-07	5.13E-07	5.06E-07	4.45E-07
HC	0	0	0	0	0	0	0	0	0	0
Lead	3.30E-07	3.33E-07	3.49E-07	3.63E-07	3.66E-07	4.70E-07	3.37E-07	3.02E-07	2.97E-07	2.62E-07
Mangane	2.51E-07	2.54E-07	2.65E-07	2.76E-07	2.78E-07	3.58E-07	2.56E-07	2.30E-07	2.26E-07	1.99E-07
Mercury	1.72E-07	1.74E-07	1.82E-07	1.89E-07	1.91E-07	2.45E-07	1.75E-07	1.57E-07	1.55E-07	1.36E-07
Methane	0	0	0	0	0	0	0	0	0	0
Molybde	7.27E-07	7.35E-07	7.68E-07	8.01E-07	8.06E-07	1.04E-06	7.42E-07	6.65E-07	6.55E-07	5.76E-07
Nickel	1.39E-06	1.40E-06	1.47E-06	1.53E-06	1.54E-06	1.98E-06	1.42E-06	1.27E-06	1.25E-06	1.10E-06
PAH	0	0	0	0	0	0	0	0	0	0
Selenium	1.58E-08	1.60E-08	1.67E-08	1.74E-08	1.75E-08	2.25E-08	1.61E-08	1.45E-08	1.43E-08	1.25E-08
TOC	7.27E-03	7.35E-03	7.68E-03	8.01E-03	8.06E-03	1.04E-02	7.42E-03	6.65E-03	6.55E-03	5.76E-03
Toluene	0	0	0	0	0	0	0	0	0	0
Vanadiu	1.53E-06	1.55E-06	1.62E-06	1.68E-06	1.70E-06	2.18E-06	1.56E-06	1.40E-06	1.38E-06	1.21E-06
VOC	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0
1.04E-06	9.03E-07	9.35E-07	1.15E-06	1.34E-06	1.61E-06	1.83E-06	1.41E-06	1.55E-06	1.64E-06
0	0	0	0	0	0	0	0	0	0
4.95E-03	4.29E-03	4.45E-03	5.46E-03	6.39E-03	7.67E-03	8.68E-03	6.71E-03	7.35E-03	7.80E-03
1.08E-08	9.34E-09	9.67E-09	1.19E-08	1.39E-08	1.67E-08	1.89E-08	1.46E-08	1.60E-08	1.70E-08
0	0	0	0	0	0	0	0	0	0
9.45E-07	8.19E-07	8.48E-07	1.04E-06	1.22E-06	1.46E-06	1.66E-06	1.28E-06	1.40E-06	1.49E-06
4.95E-07	4.29E-07	4.45E-07	5.46E-07	6.39E-07	7.67E-07	8.68E-07	6.71E-07	7.35E-07	7.80E-07
0	0	0	0	0	0	0	0	0	0
1.17E-07	1.02E-07	1.05E-07	1.29E-07	1.51E-07	1.81E-07	2.05E-07	1.59E-07	1.74E-07	1.84E-07
1.71E-07	1.48E-07	1.54E-07	1.89E-07	2.21E-07	2.65E-07	3.00E-07	2.32E-07	2.54E-07	2.69E-07
2.25E-07	1.95E-07	2.02E-07	2.48E-07	2.90E-07	3.48E-07	3.94E-07	3.04E-07	3.33E-07	3.54E-07
0	0	0	0	0	0	0	0	0	0
3.82E-07	3.31E-07	3.43E-07	4.21E-07	4.93E-07	5.91E-07	6.70E-07	5.17E-07	5.67E-07	6.01E-07
3.78E-08	3.28E-08	3.39E-08	4.17E-08	4.87E-08	5.85E-08	6.63E-08	5.12E-08	5.60E-08	5.95E-08
6.28E-07	5.45E-07	5.64E-07	6.93E-07	8.10E-07	9.73E-07	1.10E-06	8.51E-07	9.32E-07	9.89E-07
4.95E-07	4.29E-07	4.45E-07	5.46E-07	6.39E-07	7.67E-07	8.68E-07	6.71E-07	7.35E-07	7.80E-07
5.41E-09	4.69E-09	4.86E-09	5.97E-09	6.98E-09	8.38E-09	9.49E-09	7.33E-09	8.03E-09	8.52E-09
1.90E-05	1.90E-05	1.90E-05	1.90E-05	1.90E-05	1.56E-05	1.22E-05	7.85E-06	7.28E-06	6.65E-06
2.03E-06	1.76E-06	1.82E-06	2.24E-06	2.62E-06	3.15E-06	3.56E-06	2.75E-06	3.01E-06	3.20E-06
8.99E-08	7.79E-08	8.07E-08	9.91E-08	1.16E-07	1.39E-07	1.58E-07	1.22E-07	1.33E-07	1.42E-07
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4.32E-08	4.15E-08	4.19E-08	4.45E-08	4.69E-08	4.49E-08	4.21E-08	3.00E-08	3.07E-08	3.09E-08
9.30E-07	8.88E-07	8.97E-07	9.62E-07	1.02E-06	9.91E-07	9.45E-07	6.78E-07	7.00E-07	7.08E-07
1.00E-02	9.17E-03	9.36E-03	1.06E-02	1.18E-02	1.28E-02	1.34E-02	1.00E-02	1.07E-02	1.12E-02
1.37E-01	1.31E-01	1.33E-01	1.42E-01	1.51E-01	1.46E-01	1.40E-01	1.00E-01	1.03E-01	1.04E-01
1.21E-02	1.15E-02	1.16E-02	1.25E-02	1.33E-02	1.30E-02	1.25E-02	9.03E-03	9.36E-03	9.49E-03
5.02E-05	4.80E-05	4.85E-05	5.20E-05	5.51E-05	5.35E-05	5.10E-05	3.65E-05	3.77E-05	3.81E-05
4.91E-04	4.69E-04	4.74E-04	5.08E-04	5.39E-04	5.23E-04	4.99E-04	3.58E-04	3.69E-04	3.74E-04
3.49E-01	3.44E-01	3.45E-01	3.52E-01	3.59E-01	3.12E-01	2.63E-01	1.77E-01	1.72E-01	1.64E-01
1.71E-02	1.65E-02	1.66E-02	1.76E-02	1.85E-02	1.76E-02	1.65E-02	1.17E-02	1.20E-02	1.20E-02
2.60E-01	2.56E-01	2.57E-01	2.63E-01	2.69E-01	2.35E-01	2.00E-01	1.35E-01	1.32E-01	1.27E-01
4.61E-01	4.53E-01	4.55E-01	4.67E-01	4.77E-01	4.20E-01	3.60E-01	2.44E-01	2.39E-01	2.31E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-42: Hourly GWP Emissions from NGCC in January.

Perfluoropentan	0	0	0	0	0	0	0	0	0	0
Perfluorobutane	0	0	0	0	0	0	0	0	0	0
Perfluoropropane	0	0	0	0	0	0	0	0	0	0
Perfluorohexane	0	0	0	0	0	0	0	0	0	0
Perfluorocyclobu tane	0	0	0	0	0	0	0	0	0	0
Perfluoroethane	5.45E-10	5.41E-10	5.54E-10	5.64E-10	6.00E-10	9.19E-10	9.31E-10	8.92E-10	8.87E-10	8.46E-10
Perfluoromethane	4.33E-09	4.30E-09	4.41E-09	4.49E-09	4.77E-09	7.31E-09	7.41E-09	7.09E-09	7.06E-09	6.73E-09
SF6	0	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0	0
HFC-43-10mee	0	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0	0
HFC-23	0	0	0	0	0	0	0	0	0	0
N2O	1.54E-03	1.51E-03	1.51E-03	1.51E-03	1.69E-03	2.97E-03	3.62E-03	3.56E-03	3.55E-03	3.48E-03
CH4	5.06E-01	5.02E-01	5.15E-01	5.26E-01	5.57E-01	8.47E-01	8.49E-01	8.11E-01	8.06E-01	7.68E-01
CO2	1.23E+02	1.22E+02	1.25E+02	1.28E+02	1.35E+02	2.02E+02	1.97E+02	1.87E+02	1.86E+02	1.76E+02
CO2 EQ.	1.34E+02	1.33E+02	1.37E+02	1.40E+02	1.47E+02	2.21E+02	2.16E+02	2.06E+02	2.04E+02	1.94E+02
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
8.05E-10	7.71E-10	7.78E-10	8.31E-10	8.78E-10	8.47E-10	8.02E-10	5.73E-10	5.90E-10	5.95E-10
6.40E-09	6.13E-09	6.19E-09	6.61E-09	6.99E-09	6.74E-09	6.38E-09	4.56E-09	4.69E-09	4.73E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
3.41E-03	3.36E-03	3.37E-03	3.46E-03	3.53E-03	3.11E-03	2.66E-03	1.81E-03	1.77E-03	1.71E-03
7.28E-01	6.96E-01	7.03E-01	7.53E-01	7.98E-01	7.74E-01	7.37E-01	5.29E-01	5.46E-01	5.52E-01
1.66E+02	1.58E+02	1.60E+02	1.73E+02	1.84E+02	1.81E+02	1.75E+02	1.27E+02	1.31E+02	1.33E+02
1.83E+02	1.74E+02	1.76E+02	1.90E+02	2.02E+02	1.99E+02	1.92E+02	1.38E+02	1.43392E+02	1.46E+02
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-43: Hourly Primary Energy Consumption from NGCC in January.

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	6.73E+02	6.73E+02	2.98E-01	2.30E-01
Hour 4	6.69E+02	6.68E+02	2.96E-01	2.28E-01
Hour 5	6.86E+02	6.86E+02	3.04E-01	2.33E-01
Hour 6	7.00E+02	7.00E+02	3.10E-01	2.38E-01
Hour 7	7.42E+02	7.41E+02	3.28E-01	2.53E-01
Hour 8	1.13E+03	1.12E+03	4.98E-01	3.88E-01
Hour 9	1.13E+03	1.13E+03	4.99E-01	3.96E-01
Hour 10	1.08E+03	1.07E+03	4.76E-01	3.79E-01
Hour 11	1.07E+03	1.07E+03	4.74E-01	3.77E-01
Hour 12	1.02E+03	1.02E+03	4.51E-01	3.60E-01
Hour 13	9.65E+02	9.64E+02	4.27E-01	3.43E-01
Hour 14	9.21E+02	9.21E+02	4.08E-01	3.29E-01
Hour 15	9.31E+02	9.31E+02	4.13E-01	3.32E-01
Hour 16	9.98E+02	9.97E+02	4.42E-01	3.54E-01
Hour 17	1.06E+03	1.06E+03	4.69E-01	3.74E-01
Hour 18	1.03E+03	1.03E+03	4.55E-01	3.59E-01
Hour 19	9.80E+02	9.79E+02	4.34E-01	3.39E-01
Hour 20	7.03E+02	7.03E+02	3.11E-01	2.42E-01
Hour 21	7.26E+02	7.25E+02	3.21E-01	2.49E-01
Hour 22	7.34E+02	7.34E+02	3.25E-01	2.51E-01

Table H-44: Hourly Air Emissions from Average Electric Mix in January.

Zinc	1.91E-05	1.93E-05	2.02E-05	2.10E-05	2.12E-05	2.72E-05	1.95E-05	1.75E-05	1.72E-05	1.52E-05
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	3.63E-03	3.67E-03	3.84E-03	4.00E-03	4.02E-03	5.17E-03	3.70E-03	3.32E-03	3.27E-03	2.88E-03
VOC	0	0	0	0	0	0	0	0	0	0
Vanadiu	1.53E-06	1.55E-06	1.62E-06	1.68E-06	1.70E-06	2.18E-06	1.56E-06	1.40E-06	1.38E-06	1.21E-06
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	7.27E-03	7.35E-03	7.68E-03	8.01E-03	8.06E-03	1.04E-02	7.42E-03	6.65E-03	6.55E-03	5.76E-03
Selenium	1.58E-08	1.60E-08	1.67E-08	1.74E-08	1.75E-08	2.25E-08	1.61E-08	1.45E-08	1.43E-08	1.25E-08
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	1.39E-06	1.40E-06	1.47E-06	1.53E-06	1.54E-06	1.98E-06	1.42E-06	1.27E-06	1.25E-06	1.10E-06
Molybde	7.27E-07	7.35E-07	7.68E-07	8.01E-07	8.06E-07	1.04E-06	7.42E-07	6.65E-07	6.55E-07	5.76E-07
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	1.72E-07	1.74E-07	1.82E-07	1.89E-07	1.91E-07	2.45E-07	1.75E-07	1.57E-07	1.55E-07	1.36E-07
Mangane	2.51E-07	2.54E-07	2.65E-07	2.76E-07	2.78E-07	3.58E-07	2.56E-07	2.30E-07	2.26E-07	1.99E-07
Lead	3.30E-07	3.33E-07	3.49E-07	3.63E-07	3.66E-07	4.70E-07	3.37E-07	3.02E-07	2.97E-07	2.62E-07
HC	0	0	0	0	0	0	0	0	0	0
Copper	5.61E-07	5.67E-07	5.93E-07	6.17E-07	6.22E-07	7.99E-07	5.72E-07	5.13E-07	5.06E-07	4.45E-07
Cobalt	5.55E-08	5.60E-08	5.86E-08	6.11E-08	6.15E-08	7.90E-08	5.66E-08	5.07E-08	5.00E-08	4.40E-08
Chromiu	9.22E-07	9.32E-07	9.75E-07	1.02E-06	1.02E-06	1.31E-06	9.42E-07	8.44E-07	8.32E-07	7.31E-07
Cadmiu	7.27E-07	7.35E-07	7.68E-07	8.01E-07	8.06E-07	1.04E-06	7.42E-07	6.65E-07	6.55E-07	5.76E-07
Berylliu	7.94E-09	8.03E-09	8.40E-09	8.75E-09	8.81E-09	1.13E-08	8.11E-09	7.26E-09	7.16E-09	6.30E-09
Benzene	0	0	0	0	0	0	0	0	0	0
Barium	2.98E-06	3.01E-06	3.15E-06	3.28E-06	3.31E-06	4.25E-06	3.04E-06	2.73E-06	2.69E-06	2.36E-06
arsenic	1.32E-07	1.33E-07	1.39E-07	1.45E-07	1.46E-07	1.88E-07	1.35E-07	1.21E-07	1.19E-07	1.05E-07
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetalde	0	0	0	0	0	0	0	0	0	0
NH3	2.05E-06	1.96E-06	1.91E-06	1.84E-06	2.23E-06	4.63E-06	6.62E-06	6.61E-06	6.61E-06	6.61E-06
H2S	4.64E-07	4.68E-07	4.90E-07	5.10E-07	5.14E-07	6.65E-07	4.85E-07	4.36E-07	4.30E-07	3.80E-07
NMVOC	2.98E-02	2.89E-02	2.88E-02	2.85E-02	3.25E-02	5.97E-02	7.60E-02	7.50E-02	7.49E-02	7.39E-02
CO	1.20E-01	1.18E-01	1.20E-01	1.21E-01	1.32E-01	2.15E-01	2.39E-01	2.31E-01	2.31E-01	2.23E-01
Particulat	1.42E-02	1.39E-02	1.40E-02	1.40E-02	1.55E-02	2.68E-02	3.20E-02	3.13E-02	3.12E-02	3.05E-02
HF	2.63E-04	2.52E-04	2.47E-04	2.40E-04	2.86E-04	5.76E-04	7.99E-04	7.96E-04	7.96E-04	7.93E-04
HCl	5.04E-03	4.81E-03	4.71E-03	4.55E-03	5.47E-03	1.12E-02	1.58E-02	1.58E-02	1.58E-02	1.57E-02
NOx	2.63E-01	2.53E-01	2.51E-01	2.45E-01	2.86E-01	5.53E-01	7.39E-01	7.34E-01	7.33E-01	7.27E-01
SO2	7.17E-02	6.87E-02	6.75E-02	6.54E-02	7.79E-02	1.56E-01	2.16E-01	2.16E-01	2.15E-01	2.15E-01
SO2 eq.	2.60E-01	2.50E-01	2.46E-01	2.41E-01	2.83E-01	5.52E-01	7.46E-01	7.41E-01	7.41E-01	7.36E-01
TOPP eq.	3.71E-01	3.58E-01	3.55E-01	3.48E-01	4.04E-01	7.70E-01	1.02E+0	1.01E+0	1.01E+0	9.97E-01
Option	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

1.30E-05	1.13E-05	1.17E-05	1.44E-05	1.68E-05	2.02E-05	2.28E-05	1.76E-05	1.93E-05	2.05E-05
0	0	0	0	0	0	0	0	0	0
2.47E-03	2.14E-03	2.22E-03	2.73E-03	3.19E-03	3.83E-03	4.33E-03	3.35E-03	3.67E-03	3.89E-03
0	0	0	0	0	0	0	0	0	0
1.04E-06	9.03E-07	9.35E-07	1.15E-06	1.34E-06	1.61E-06	1.83E-06	1.41E-06	1.55E-06	1.64E-06
0	0	0	0	0	0	0	0	0	0
4.95E-03	4.29E-03	4.45E-03	5.46E-03	6.39E-03	7.67E-03	8.68E-03	6.71E-03	7.35E-03	7.80E-03
1.08E-08	9.34E-09	9.67E-09	1.19E-08	1.39E-08	1.67E-08	1.89E-08	1.46E-08	1.60E-08	1.70E-08
0	0	0	0	0	0	0	0	0	0
9.45E-07	8.19E-07	8.48E-07	1.04E-06	1.22E-06	1.46E-06	1.66E-06	1.28E-06	1.40E-06	1.49E-06
4.95E-07	4.29E-07	4.45E-07	5.46E-07	6.39E-07	7.67E-07	8.68E-07	6.71E-07	7.35E-07	7.80E-07
0	0	0	0	0	0	0	0	0	0
1.17E-07	1.02E-07	1.05E-07	1.29E-07	1.51E-07	1.81E-07	2.05E-07	1.59E-07	1.74E-07	1.84E-07
1.71E-07	1.48E-07	1.54E-07	1.89E-07	2.21E-07	2.65E-07	3.00E-07	2.32E-07	2.54E-07	2.69E-07
2.25E-07	1.95E-07	2.02E-07	2.48E-07	2.90E-07	3.48E-07	3.94E-07	3.04E-07	3.33E-07	3.54E-07
0	0	0	0	0	0	0	0	0	0
3.82E-07	3.31E-07	3.43E-07	4.21E-07	4.93E-07	5.91E-07	6.70E-07	5.17E-07	5.67E-07	6.01E-07
3.78E-08	3.28E-08	3.39E-08	4.17E-08	4.87E-08	5.85E-08	6.63E-08	5.12E-08	5.60E-08	5.95E-08
6.28E-07	5.45E-07	5.64E-07	6.93E-07	8.10E-07	9.73E-07	1.10E-06	8.51E-07	9.32E-07	9.89E-07
4.95E-07	4.29E-07	4.45E-07	5.46E-07	6.39E-07	7.67E-07	8.68E-07	6.71E-07	7.35E-07	7.80E-07
5.41E-09	4.69E-09	4.86E-09	5.97E-09	6.98E-09	8.38E-09	9.49E-09	7.33E-09	8.03E-09	8.52E-09
0	0	0	0	0	0	0	0	0	0
2.03E-06	1.76E-06	1.82E-06	2.24E-06	2.62E-06	3.15E-06	3.56E-06	2.75E-06	3.01E-06	3.20E-06
8.99E-08	7.79E-08	8.07E-08	9.91E-08	1.16E-07	1.39E-07	1.58E-07	1.22E-07	1.33E-07	1.42E-07
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
6.61E-06	6.61E-06	6.61E-06	6.61E-06	6.61E-06	5.44E-06	4.26E-06	2.74E-06	2.54E-06	2.33E-06
3.29E-07	2.87E-07	2.97E-07	3.61E-07	4.19E-07	4.97E-07	5.58E-07	4.30E-07	4.70E-07	4.98E-07
7.29E-02	7.21E-02	7.22E-02	7.35E-02	7.47E-02	6.44E-02	5.39E-02	3.60E-02	3.48E-02	3.32E-02
2.16E-01	2.09E-01	2.11E-01	2.20E-01	2.29E-01	2.11E-01	1.90E-01	1.32E-01	1.33E-01	1.32E-01
2.98E-02	2.92E-02	2.94E-02	3.03E-02	3.11E-02	2.76E-02	2.39E-02	1.64E-02	1.61E-02	1.57E-02
7.90E-04	7.88E-04	7.88E-04	7.92E-04	7.95E-04	6.61E-04	5.27E-04	3.42E-04	3.21E-04	2.97E-04
1.57E-02	1.57E-02	1.57E-02	1.57E-02	1.58E-02	1.30E-02	1.03E-02	6.64E-03	6.20E-03	5.69E-03
7.22E-01	7.17E-01	7.18E-01	7.25E-01	7.32E-01	6.18E-01	5.03E-01	3.31E-01	3.15E-01	2.95E-01
2.14E-01	2.13E-01	2.13E-01	2.14E-01	2.15E-01	1.79E-01	1.43E-01	9.29E-02	8.73E-02	8.08E-02
7.31E-01	7.28E-01	7.28E-01	7.34E-01	7.40E-01	6.22E-01	5.03E-01	3.29E-01	3.12E-01	2.92E-01
9.87E-01	9.80E-01	9.81E-01	9.93E-01	1.00E+0	8.53E-01	6.98E-01	4.61E-01	4.41E-01	4.15E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-45: Hourly GWP Emissions from Average Electric Mix in January.

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
CO2	1.63E+0	1.61E+0	1.64E+0	1.66E+0	1.79E+0	2.87E+0	3.12E+0	3.01E+0	3.00E+0	2.89E+0
CO2	1.51E+0	1.49E+0	1.52E+0	1.54E+0	1.66E+0	2.67E+0	2.90E+0	2.81E+0	2.79E+0	2.70E+0
CH4	5.07E-01	5.04E-01	5.17E-01	5.27E-01	5.59E-01	8.50E-01	8.53E-01	8.16E-01	8.11E-01	7.72E-01
N2O	3.96E-03	3.81E-03	3.76E-03	3.66E-03	4.31E-03	8.46E-03	1.15E-02	1.14E-02	1.14E-02	1.13E-02
HFC-23	0	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0	0
HFC-43-	0	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0	0
SF6	0	0	0	0	0	0	0	0	0	0
Perfluorometha	2.37E-07	2.26E-07	2.21E-07	2.12E-07	2.58E-07	5.35E-07	7.63E-07	7.63E-07	7.63E-07	7.62E-07
Perfluoroethan	2.98E-08	2.84E-08	2.77E-08	2.67E-08	3.24E-08	6.73E-08	9.59E-08	9.59E-08	9.58E-08	9.58E-08
Perfluorocyclo	0	0	0	0	0	0	0	0	0	0
Perfluorohexan	0	0	0	0	0	0	0	0	0	0
Perfluoropropa	0	0	0	0	0	0	0	0	0	0
Perfluorobutan	0	0	0	0	0	0	0	0	0	0
Perfluoropenta	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
9.58E-08	9.57E-08	9.57E-08	9.58E-08	9.58E-08	7.89E-08	6.19E-08	3.98E-08	3.69E-08	3.38E-08
7.62E-07	7.62E-07	7.62E-07	7.62E-07	7.63E-07	6.27E-07	4.92E-07	3.16E-07	2.94E-07	2.69E-07
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1.13E-02	1.12E-02	1.12E-02	1.13E-02	1.14E-02	9.56E-03	7.71E-03	5.04E-03	4.78E-03	4.45E-03
7.33E-01	7.00E-01	7.08E-01	7.58E-01	8.03E-01	7.78E-01	7.40E-01	5.31E-01	5.47E-01	5.53E-01
2.60E+0	2.51E+0	2.53E+0	2.66E+0	2.77E+0	2.58E+0	2.35E+0	1.65E+0	1.67E+0	1.66E+0
2.78E+0	2.70E+0	2.72E+0	2.85E+0	2.98E+0	2.77E+0	2.53E+0	1.78E+0	1.80E+0	1.79E+0
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-46: Hourly Primary Energy Consumption from Average Electric Mix in January.

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	7.32E+02	7.07E+02	8.35E+00	1.66E+01
Hour 4	7.25E+02	7.01E+02	7.96E+00	1.58E+01
Hour 5	7.41E+02	7.17E+02	7.77E+00	1.54E+01
Hour 6	7.52E+02	7.30E+02	7.49E+00	1.48E+01
Hour 7	8.05E+02	7.78E+02	9.06E+00	1.80E+01
Hour 8	1.26E+03	1.20E+03	1.87E+01	3.75E+01
Hour 9	1.32E+03	1.24E+03	2.66E+01	5.35E+01
Hour 10	1.27E+03	1.19E+03	2.66E+01	5.35E+01
Hour 11	1.26E+03	1.18E+03	2.66E+01	5.35E+01
Hour 12	1.21E+03	1.13E+03	2.65E+01	5.34E+01
Hour 13	1.15E+03	1.07E+03	2.65E+01	5.34E+01
Hour 14	1.11E+03	1.03E+03	2.65E+01	5.34E+01
Hour 15	1.12E+03	1.04E+03	2.65E+01	5.34E+01
Hour 16	1.19E+03	1.11E+03	2.65E+01	5.34E+01
Hour 17	1.25E+03	1.17E+03	2.66E+01	5.35E+01
Hour 18	1.18E+03	1.12E+03	2.19E+01	4.40E+01
Hour 19	1.10E+03	1.05E+03	1.72E+01	3.45E+01
Hour 20	7.82E+02	7.48E+02	1.11E+01	2.21E+01
Hour 21	7.99E+02	7.68E+02	1.03E+01	2.06E+01
Hour 22	8.00E+02	7.72E+02	9.44E+00	1.88E+01

Table H-47: Hourly Air Emissions from NGCC (EC) in May.

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Zinc	2.97E-07	2.97E-07	2.97E-07	2.97E-07	2.97E-07	1.04E-06	9.41E-07	9.41E-07	9.41E-07	1.04E-06
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	5.64E-05	5.64E-05	5.64E-05	5.64E-05	5.64E-05	1.97E-04	1.79E-04	1.79E-04	1.79E-04	1.97E-04
VOC	0	0	0	0	0	0	0	0	0	0
Vanadium	2.38E-08	2.38E-08	2.38E-08	2.38E-08	2.38E-08	8.32E-08	7.53E-08	7.53E-08	7.53E-08	8.32E-08
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	3.96E-04	3.58E-04	3.58E-04	3.58E-04	3.96E-04
Selenium	2.46E-10	2.46E-10	2.46E-10	2.46E-10	2.46E-10	8.61E-10	7.79E-10	7.79E-10	7.79E-10	8.61E-10
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	2.16E-08	2.16E-08	2.16E-08	2.16E-08	2.16E-08	7.54E-08	6.83E-08	6.83E-08	6.83E-08	7.54E-08
Molybdenum	1.13E-08	1.13E-08	1.13E-08	1.13E-08	1.13E-08	3.96E-08	3.58E-08	3.58E-08	3.58E-08	3.96E-08
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	2.67E-09	2.67E-09	2.67E-09	2.67E-09	2.67E-09	9.35E-09	8.46E-09	8.46E-09	8.46E-09	9.35E-09
Manganese	3.90E-09	3.90E-09	3.90E-09	3.90E-09	3.90E-09	1.37E-08	1.24E-08	1.24E-08	1.24E-08	1.37E-08
Lead	5.13E-09	5.13E-09	5.13E-09	5.13E-09	5.13E-09	1.79E-08	1.62E-08	1.62E-08	1.62E-08	1.79E-08
HC	0	0	0	0	0	0	0	0	0	0
Copper	8.72E-09	8.72E-09	8.72E-09	8.72E-09	8.72E-09	3.05E-08	2.76E-08	2.76E-08	2.76E-08	3.05E-08
Cobalt	8.62E-10	8.62E-10	8.62E-10	8.62E-10	8.62E-10	3.02E-09	2.73E-09	2.73E-09	2.73E-09	3.02E-09
Chromium	1.43E-08	1.43E-08	1.43E-08	1.43E-08	1.43E-08	5.02E-08	4.54E-08	4.54E-08	4.54E-08	5.02E-08
Cadmium	1.13E-08	1.13E-08	1.13E-08	1.13E-08	1.13E-08	3.96E-08	3.58E-08	3.58E-08	3.58E-08	3.96E-08
Beryllium	1.23E-10	1.23E-10	1.23E-10	1.23E-10	1.23E-10	4.32E-10	3.91E-10	3.91E-10	3.91E-10	4.32E-10
Benzene	4.74E-06	4.45E-06	4.24E-06	4.03E-06	5.09E-06	1.52E-05	2.28E-05	2.32E-05	2.43E-05	2.50E-05
Barium	4.64E-08	4.64E-08	4.64E-08	4.64E-08	4.64E-08	1.62E-07	1.47E-07	1.47E-07	1.47E-07	1.62E-07
arsenic	2.05E-09	2.05E-09	2.05E-09	2.05E-09	2.05E-09	7.18E-09	6.50E-09	6.50E-09	6.50E-09	7.18E-09
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehyde	0	0	0	0	0	0	0	0	0	0
NH3	7.85E-09	7.39E-09	7.06E-09	6.71E-09	8.40E-09	2.59E-08	3.84E-08	3.91E-08	4.13E-08	4.27E-08
H2S	1.61E-07	1.52E-07	1.45E-07	1.38E-07	1.72E-07	5.19E-07	7.61E-07	7.75E-07	8.11E-07	8.36E-07
NMVOC	1.07E-03	1.01E-03	9.72E-04	9.31E-04	1.14E-03	3.48E-03	4.91E-03	4.99E-03	5.21E-03	5.39E-03
CO	2.38E-02	2.25E-02	2.14E-02	2.04E-02	2.55E-02	7.70E-02	1.13E-01	1.15E-01	1.21E-01	1.24E-01
Particulates	2.04E-03	1.92E-03	1.83E-03	1.75E-03	2.18E-03	6.58E-03	9.64E-03	9.82E-03	1.03E-02	1.06E-02
HF	8.71E-06	8.21E-06	7.84E-06	7.47E-06	9.33E-06	2.81E-05	4.13E-05	4.20E-05	4.40E-05	4.53E-05
HCl	8.50E-05	8.01E-05	7.65E-05	7.29E-05	9.10E-05	2.74E-04	4.03E-04	4.10E-04	4.29E-04	4.42E-04
NOx	7.90E-02	7.43E-02	7.08E-02	6.73E-02	8.48E-02	2.54E-01	3.78E-01	3.85E-01	4.04E-01	4.16E-01
SO2	3.15E-03	2.97E-03	2.83E-03	2.69E-03	3.37E-03	1.02E-02	1.50E-02	1.52E-02	1.60E-02	1.65E-02
SO2 eq.	5.82E-02	5.48E-02	5.22E-02	4.96E-02	6.25E-02	1.87E-01	2.79E-01	2.84E-01	2.98E-01	3.06E-01
TOPP eq.	1.02E-01	9.58E-02	9.13E-02	8.68E-02	1.09E-01	3.28E-01	4.87E-01	4.96E-01	5.20E-01	5.35E-01

9.41E-07	9.41E-07	9.41E-07	1.04E-06	1.04E-06	8.42E-07	5.94E-07	3.96E-07	2.97E-07	2.97E-07
0	0	0	0	0	0	0	0	0	0
1.79E-04	1.79E-04	1.79E-04	1.97E-04	1.97E-04	1.60E-04	1.13E-04	7.52E-05	5.64E-05	5.64E-05
0	0	0	0	0	0	0	0	0	0
7.53E-08	7.53E-08	7.53E-08	8.32E-08	8.32E-08	6.74E-08	4.75E-08	3.17E-08	2.38E-08	2.38E-08
0	0	0	0	0	0	0	0	0	0
3.58E-04	3.58E-04	3.58E-04	3.96E-04	3.96E-04	3.20E-04	2.26E-04	1.51E-04	1.13E-04	1.13E-04
7.79E-10	7.79E-10	7.79E-10	8.61E-10	8.61E-10	6.97E-10	4.92E-10	3.28E-10	2.46E-10	2.46E-10
0	0	0	0	0	0	0	0	0	0
6.83E-08	6.83E-08	6.83E-08	7.54E-08	7.54E-08	6.11E-08	4.31E-08	2.87E-08	2.16E-08	2.16E-08
3.58E-08	3.58E-08	3.58E-08	3.96E-08	3.96E-08	3.20E-08	2.26E-08	1.51E-08	1.13E-08	1.13E-08
0	0	0	0	0	0	0	0	0	0
8.46E-09	8.46E-09	8.46E-09	9.35E-09	9.35E-09	7.57E-09	5.34E-09	3.56E-09	2.67E-09	2.67E-09
1.24E-08	1.24E-08	1.24E-08	1.37E-08	1.37E-08	1.11E-08	7.81E-09	5.20E-09	3.90E-09	3.90E-09
1.62E-08	1.62E-08	1.62E-08	1.79E-08	1.79E-08	1.45E-08	1.03E-08	6.84E-09	5.13E-09	5.13E-09
0	0	0	0	0	0	0	0	0	0
2.76E-08	2.76E-08	2.76E-08	3.05E-08	3.05E-08	2.47E-08	1.74E-08	1.16E-08	8.72E-09	8.72E-09
2.73E-09	2.73E-09	2.73E-09	3.02E-09	3.02E-09	2.44E-09	1.72E-09	1.15E-09	8.62E-10	8.62E-10
4.54E-08	4.54E-08	4.54E-08	5.02E-08	5.02E-08	4.06E-08	2.87E-08	1.91E-08	1.43E-08	1.43E-08
3.58E-08	3.58E-08	3.58E-08	3.96E-08	3.96E-08	3.20E-08	2.26E-08	1.51E-08	1.13E-08	1.13E-08
3.91E-10	3.91E-10	3.91E-10	4.32E-10	4.32E-10	3.50E-10	2.47E-10	1.65E-10	1.23E-10	1.23E-10
2.47E-05	2.46E-05	2.44E-05	2.55E-05	2.59E-05	2.22E-05	1.74E-05	1.09E-05	7.88E-06	6.07E-06
1.47E-07	1.47E-07	1.47E-07	1.62E-07	1.62E-07	1.31E-07	9.27E-08	6.18E-08	4.64E-08	4.64E-08
6.50E-09	6.50E-09	6.50E-09	7.18E-09	7.18E-09	5.81E-09	4.10E-09	2.74E-09	2.05E-09	2.05E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4.20E-08	4.19E-08	4.15E-08	4.36E-08	4.44E-08	3.81E-08	2.99E-08	1.88E-08	1.33E-08	1.01E-08
8.24E-07	8.20E-07	8.15E-07	8.52E-07	8.66E-07	7.39E-07	5.79E-07	3.64E-07	2.63E-07	2.04E-07
5.29E-03	5.26E-03	5.23E-03	5.49E-03	5.57E-03	4.74E-03	3.69E-03	2.33E-03	1.68E-03	1.33E-03
1.22E-01	1.22E-01	1.21E-01	1.27E-01	1.29E-01	1.10E-01	8.62E-02	5.42E-02	3.90E-02	3.02E-02
1.04E-02	1.04E-02	1.03E-02	1.08E-02	1.10E-02	9.37E-03	7.35E-03	4.62E-03	3.33E-03	2.58E-03
4.47E-05	4.45E-05	4.42E-05	4.62E-05	4.70E-05	4.01E-05	3.14E-05	1.97E-05	1.42E-05	1.11E-05
4.36E-04	4.34E-04	4.31E-04	4.51E-04	4.58E-04	3.91E-04	3.07E-04	1.93E-04	1.39E-04	1.08E-04
4.11E-01	4.09E-01	4.06E-01	4.24E-01	4.31E-01	3.68E-01	2.89E-01	1.82E-01	1.31E-01	1.01E-01
1.62E-02	1.62E-02	1.61E-02	1.68E-02	1.71E-02	1.46E-02	1.14E-02	7.18E-03	5.17E-03	4.00E-03
3.03E-01	3.01E-01	2.99E-01	3.12E-01	3.18E-01	2.71E-01	2.13E-01	1.34E-01	9.64E-02	7.44E-02
5.29E-01	5.26E-01	5.23E-01	5.46E-01	5.55E-01	4.74E-01	3.72E-01	2.34E-01	1.68E-01	1.30E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-48: Hourly GWP Emissions from NGCC (EC) in May.

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Perfluoropentan	0	0	0	0	0	0	0	0	0	0
Perfluorobutane	0	0	0	0	0	0	0	0	0	0
Perfluoropropane	0	0	0	0	0	0	0	0	0	0
Perfluorohexane	0	0	0	0	0	0	0	0	0	0
Perfluorocyclobutane	0	0	0	0	0	0	0	0	0	0
Perfluoroethane	1.43E-10	1.35E-10	1.28E-10	1.22E-10	1.53E-10	4.71E-10	6.96E-10	7.10E-10	7.48E-10	7.74E-10
Perfluoromethane	1.14E-09	1.07E-09	1.02E-09	9.72E-10	1.22E-09	3.75E-09	5.54E-09	5.65E-09	5.95E-09	6.16E-09
SF6	0	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0	0
HFC-43-10mee	0	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0	0
HFC-23	0	0	0	0	0	0	0	0	0	0
N2O	7.54E-04	7.10E-04	6.76E-04	6.43E-04	8.10E-04	2.43E-03	3.61E-03	3.68E-03	3.85E-03	3.97E-03
CH4	1.26E-01	1.19E-01	1.14E-01	1.08E-01	1.35E-01	4.08E-01	5.99E-01	6.09E-01	6.38E-01	6.58E-01
CO2	2.75E+01	2.60E+01	2.48E+01	2.36E+01	2.95E+01	8.89E+01	1.30E+02	1.32E+02	1.39E+02	1.43E+02
CO2 eq.	3.0414E+01	2.8689E+01	2.74E+01	2.61E+01	3.26E+01	9.82E+01	1.44E+02	1.46E+02	1.53E+02	1.58E+02

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
7.62E-10	7.57E-10	7.52E-10	7.90E-10	8.05E-10	6.90E-10	5.42E-10	3.40E-10	2.40E-10	1.84E-10
6.06E-09	6.03E-09	5.99E-09	6.29E-09	6.41E-09	5.49E-09	4.31E-09	2.71E-09	1.91E-09	1.47E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
3.92E-03	3.90E-03	3.87E-03	4.04E-03	4.11E-03	3.51E-03	2.76E-03	1.73E-03	1.25E-03	9.64E-04
6.48E-01	6.45E-01	6.41E-01	6.70E-01	6.81E-01	5.81E-01	4.56E-01	2.86E-01	2.06E-01	1.60E-01
1.41E+02	1.40E+02	1.39E+02	1.46E+02	1.48E+02	1.26E+02	9.89E+01	6.22E+01	4.48E+01	3.49E+01
1.56E+02	1.55E+02	1.54E+02	1.61E+02	1.64E+02	1.39E+02	1.09E+02	6.87E+01	4.96E+01	3.85E+01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-49: Hourly Primary Energy Consumption from NGCC (EC) in May.

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	1.67E+02	1.67E+02	7.40E-02	6.12E-02
Hour 4	1.57E+02	1.57E+02	6.98E-02	5.77E-02
Hour 5	1.50E+02	1.50E+02	6.66E-02	5.51E-02
Hour 6	1.43E+02	1.43E+02	6.34E-02	5.24E-02
Hour 7	1.79E+02	1.79E+02	7.93E-02	6.56E-02
Hour 8	5.39E+02	5.38E+02	2.39E-01	2.01E-01
Hour 9	7.90E+02	7.90E+02	3.51E-01	2.98E-01
Hour 10	8.05E+02	8.04E+02	3.57E-01	3.04E-01
Hour 11	8.42E+02	8.42E+02	3.74E-01	3.20E-01
Hour 12	8.68E+02	8.68E+02	3.85E-01	3.31E-01
Hour 13	8.56E+02	8.55E+02	3.80E-01	3.26E-01
Hour 14	8.52E+02	8.51E+02	3.78E-01	3.24E-01
Hour 15	8.47E+02	8.46E+02	3.76E-01	3.22E-01
Hour 16	8.84E+02	8.84E+02	3.93E-01	3.38E-01
Hour 17	8.99E+02	8.99E+02	3.99E-01	3.44E-01
Hour 18	7.67E+02	7.67E+02	3.41E-01	2.95E-01
Hour 19	6.02E+02	6.01E+02	2.67E-01	2.31E-01
Hour 20	3.78E+02	3.78E+02	1.68E-01	1.45E-01
Hour 21	2.73E+02	2.72E+02	1.21E-01	1.03E-01
Hour 22	2.12E+02	2.12E+02	9.40E-02	7.88E-02

Table H-50: Hourly Air Emissions from NGCC (AC) in May.

Zinc	2.97E-07	2.97E-07	2.97E-07	2.97E-07	2.97E-07	6.98E-06	1.24E-05	1.37E-05	1.72E-05	1.94E-05
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	5.64E-05	5.64E-05	5.64E-05	5.64E-05	5.64E-05	1.33E-03	2.36E-03	2.60E-03	3.26E-03	3.68E-03
VOC	0	0	0	0	0	0	0	0	0	0
Vanadiu	2.38E-08	2.38E-08	2.38E-08	2.38E-08	2.38E-08	5.59E-07	9.96E-07	1.10E-06	1.37E-06	1.55E-06
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	2.66E-03	4.73E-03	5.22E-03	6.53E-03	7.37E-03
Selenium	2.46E-10	2.46E-10	2.46E-10	2.46E-10	2.46E-10	5.78E-09	1.03E-08	1.14E-08	1.42E-08	1.60E-08
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	2.16E-08	2.16E-08	2.16E-08	2.16E-08	2.16E-08	5.06E-07	9.03E-07	9.95E-07	1.25E-06	1.41E-06
Molybde	1.13E-08	1.13E-08	1.13E-08	1.13E-08	1.13E-08	2.66E-07	4.73E-07	5.22E-07	6.53E-07	7.37E-07
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	2.67E-09	2.67E-09	2.67E-09	2.67E-09	2.67E-09	6.28E-08	1.12E-07	1.23E-07	1.54E-07	1.74E-07
Mangane	3.90E-09	3.90E-09	3.90E-09	3.90E-09	3.90E-09	9.17E-08	1.64E-07	1.80E-07	2.25E-07	2.55E-07
Lead	5.13E-09	5.13E-09	5.13E-09	5.13E-09	5.13E-09	1.21E-07	2.15E-07	2.37E-07	2.96E-07	3.35E-07
HC	0	0	0	0	0	0	0	0	0	0
Copper	8.72E-09	8.72E-09	8.72E-09	8.72E-09	8.72E-09	2.05E-07	3.65E-07	4.03E-07	5.04E-07	5.69E-07
Cobalt	8.62E-10	8.62E-10	8.62E-10	8.62E-10	8.62E-10	2.03E-08	3.61E-08	3.98E-08	4.98E-08	5.63E-08
Chromiu	1.43E-08	1.43E-08	1.43E-08	1.43E-08	1.43E-08	3.37E-07	6.01E-07	6.62E-07	8.28E-07	9.35E-07
Cadmiu	1.13E-08	1.13E-08	1.13E-08	1.13E-08	1.13E-08	2.66E-07	4.73E-07	5.22E-07	6.53E-07	7.37E-07
Berylliu	1.23E-10	1.23E-10	1.23E-10	1.23E-10	1.23E-10	2.90E-09	5.17E-09	5.70E-09	7.13E-09	8.06E-09
Benzene	4.74E-06	4.45E-06	4.24E-06	4.03E-06	5.09E-06	1.33E-05	1.90E-05	1.90E-05	1.90E-05	1.90E-05
Barium	4.64E-08	4.64E-08	4.64E-08	4.64E-08	4.64E-08	1.09E-06	1.94E-06	2.14E-06	2.68E-06	3.03E-06
arsenic	2.05E-09	2.05E-09	2.05E-09	2.05E-09	2.05E-09	4.82E-08	8.59E-08	9.47E-08	1.19E-07	1.34E-07
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetalde	0	0	0	0	0	0	0	0	0	0
NH3	7.85E-09	7.39E-09	7.06E-09	6.71E-09	8.40E-09	4.92E-08	8.36E-08	8.93E-08	1.05E-07	1.15E-07
H2S	1.61E-07	1.52E-07	1.45E-07	1.38E-07	1.72E-07	5.99E-07	9.16E-07	9.46E-07	1.03E-06	1.08E-06
NMVOC	1.07E-03	1.01E-03	9.72E-04	9.31E-04	1.14E-03	6.18E-03	1.01E-02	1.08E-02	1.26E-02	1.37E-02
CO	2.38E-02	2.25E-02	2.14E-02	2.04E-02	2.55E-02	8.92E-02	1.37E-01	1.41E-01	1.54E-01	1.62E-01
Particulat	2.04E-03	1.92E-03	1.83E-03	1.75E-03	2.18E-03	7.83E-03	1.21E-02	1.25E-02	1.37E-02	1.45E-02
HF	8.71E-06	8.21E-06	7.84E-06	7.47E-06	9.33E-06	3.48E-05	5.42E-05	5.64E-05	6.22E-05	6.60E-05
HCl	8.50E-05	8.01E-05	7.65E-05	7.29E-05	9.10E-05	3.65E-04	5.78E-04	6.05E-04	6.77E-04	7.22E-04
NOx	7.90E-02	7.43E-02	7.08E-02	6.73E-02	8.48E-02	2.40E-01	3.51E-01	3.55E-01	3.66E-01	3.72E-01
SO2	3.15E-03	2.97E-03	2.83E-03	2.69E-03	3.37E-03	1.18E-02	1.82E-02	1.88E-02	2.05E-02	2.16E-02
SO2	5.82E-02	5.48E-02	5.22E-02	4.96E-02	6.25E-02	1.79E-01	2.63E-01	2.67E-01	2.76E-01	2.82E-01
TOPP eq.	1.02E-01	9.58E-02	9.13E-02	8.68E-02	1.09E-01	3.16E-01	4.64E-01	4.70E-01	4.87E-01	4.98E-01
Option	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

1.84E-05	1.80E-05	1.75E-05	2.09E-05	2.22E-05	2.08E-05	1.65E-05	1.05E-05	4.50E-06	2.00E-06
0	0	0	0	0	0	0	0	0	0
3.49E-03	3.42E-03	3.33E-03	3.96E-03	4.22E-03	3.96E-03	3.13E-03	1.99E-03	8.53E-04	3.79E-04
0	0	0	0	0	0	0	0	0	0
1.47E-06	1.44E-06	1.40E-06	1.67E-06	1.78E-06	1.67E-06	1.32E-06	8.39E-07	3.60E-07	1.60E-07
0	0	0	0	0	0	0	0	0	0
7.00E-03	6.85E-03	6.67E-03	7.93E-03	8.45E-03	7.93E-03	6.27E-03	3.99E-03	1.71E-03	7.59E-04
1.52E-08	1.49E-08	1.45E-08	1.73E-08	1.84E-08	1.72E-08	1.36E-08	8.68E-09	3.72E-09	1.65E-09
0	0	0	0	0	0	0	0	0	0
1.33E-06	1.31E-06	1.27E-06	1.51E-06	1.61E-06	1.51E-06	1.20E-06	7.61E-07	3.26E-07	1.45E-07
7.00E-07	6.85E-07	6.67E-07	7.93E-07	8.45E-07	7.93E-07	6.27E-07	3.99E-07	1.71E-07	7.59E-08
0	0	0	0	0	0	0	0	0	0
1.65E-07	1.62E-07	1.58E-07	1.87E-07	2.00E-07	1.87E-07	1.48E-07	9.43E-08	4.04E-08	1.79E-08
2.42E-07	2.37E-07	2.30E-07	2.74E-07	2.92E-07	2.74E-07	2.17E-07	1.38E-07	5.90E-08	2.62E-08
3.17E-07	3.11E-07	3.03E-07	3.60E-07	3.83E-07	3.60E-07	2.85E-07	1.81E-07	7.76E-08	3.44E-08
0	0	0	0	0	0	0	0	0	0
5.40E-07	5.28E-07	5.15E-07	6.12E-07	6.52E-07	6.11E-07	4.84E-07	3.08E-07	1.32E-07	5.85E-08
5.34E-08	5.23E-08	5.09E-08	6.05E-08	6.45E-08	6.05E-08	4.79E-08	3.04E-08	1.30E-08	5.79E-09
8.87E-07	8.69E-07	8.46E-07	1.01E-06	1.07E-06	1.01E-06	7.96E-07	5.06E-07	2.17E-07	9.63E-08
7.00E-07	6.85E-07	6.67E-07	7.93E-07	8.45E-07	7.93E-07	6.27E-07	3.99E-07	1.71E-07	7.59E-08
7.64E-09	7.49E-09	7.29E-09	8.66E-09	9.23E-09	8.66E-09	6.85E-09	4.36E-09	1.87E-09	8.29E-10
1.90E-05	1.90E-05	1.90E-05	1.90E-05	1.90E-05	1.56E-05	1.22E-05	7.64E-06	6.51E-06	5.52E-06
2.87E-06	2.81E-06	2.74E-06	3.25E-06	3.47E-06	3.25E-06	2.57E-06	1.64E-06	7.01E-07	3.11E-07
1.27E-07	1.24E-07	1.21E-07	1.44E-07	1.53E-07	1.44E-07	1.14E-07	7.24E-08	3.10E-08	1.38E-08
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1.11E-07	1.09E-07	1.07E-07	1.21E-07	1.28E-07	1.17E-07	9.23E-08	5.84E-08	2.97E-08	1.68E-08
1.06E-06	1.05E-06	1.04E-06	1.12E-06	1.15E-06	1.01E-06	7.93E-07	5.00E-07	3.19E-07	2.27E-07
1.32E-02	1.30E-02	1.28E-02	1.45E-02	1.52E-02	1.38E-02	1.09E-02	6.91E-03	3.59E-03	2.10E-03
1.58E-01	1.57E-01	1.55E-01	1.67E-01	1.72E-01	1.51E-01	1.19E-01	7.49E-02	4.76E-02	3.37E-02
1.41E-02	1.40E-02	1.38E-02	1.50E-02	1.54E-02	1.36E-02	1.07E-02	6.74E-03	4.21E-03	2.94E-03
6.43E-05	6.37E-05	6.29E-05	6.85E-05	7.08E-05	6.25E-05	4.92E-05	3.11E-05	1.90E-05	1.30E-05
7.02E-04	6.94E-04	6.85E-04	7.53E-04	7.81E-04	6.95E-04	5.49E-04	3.46E-04	2.03E-04	1.34E-04
3.69E-01	3.68E-01	3.67E-01	3.77E-01	3.81E-01	3.21E-01	2.52E-01	1.58E-01	1.21E-01	9.70E-02
2.11E-02	2.09E-02	2.07E-02	2.23E-02	2.30E-02	2.01E-02	1.59E-02	9.99E-03	6.34E-03	4.48E-03
2.79E-01	2.78E-01	2.77E-01	2.85E-01	2.89E-01	2.44E-01	1.92E-01	1.20E-01	9.07E-02	7.21E-02
4.93E-01	4.91E-01	4.89E-01	5.05E-01	5.12E-01	4.33E-01	3.40E-01	2.13E-01	1.60E-01	1.27E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-51: Hourly GWP Emissions from NGCC (AC) in May.

Perfluoropen	0	0	0	0	0	0	0	0	0	0
Perfluorobut	0	0	0	0	0	0	0	0	0	0
Perfluoropro	0	0	0	0	0	0	0	0	0	0
Perfluorohex	0	0	0	0	0	0	0	0	0	0
Perfluorocyc	0	0	0	0	0	0	0	0	0	0
Perfluoroeth	1.43E-10	1.35E-10	1.28E-10	1.22E-10	1.53E-10	8.31E-10	1.39E-09	1.49E-09	1.73E-09	1.89E-09
Perfluoromet	1.14E-09	1.07E-09	1.02E-09	9.72E-10	1.22E-09	6.61E-09	1.11E-08	1.18E-08	1.38E-08	1.50E-08
SF6	0	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0	0
HFC-43-	0	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0	0
HFC-23	0	0	0	0	0	0	0	0	0	0
N2O	7.54E-04	7.10E-04	6.76E-04	6.43E-04	8.10E-04	2.35E-03	3.46E-03	3.51E-03	3.64E-03	3.72E-03
CH4	1.26E-01	1.19E-01	1.14E-01	1.08E-01	1.35E-01	4.71E-01	7.20E-01	7.44E-01	8.09E-01	8.51E-01
CO2	2.75E+0	2.60E+0	2.48E+0	2.36E+0	2.95E+0	1.07E+0	1.65E+0	1.71E+0	1.88E+0	1.98E+0
CO2 Eq.	3.04E+0	2.87E+0	2.74E+0	2.61E+0	3.26E+0	1.18E+0	1.81E+0	1.88E+0	2.06E+0	2.17E+0
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1.82E-09	1.79E-09	1.76E-09	1.99E-09	2.09E-09	1.90E-09	1.50E-09	9.51E-10	4.95E-10	2.87E-10
1.45E-08	1.43E-08	1.40E-08	1.58E-08	1.66E-08	1.51E-08	1.20E-08	7.57E-09	3.94E-09	2.28E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
3.69E-03	3.67E-03	3.65E-03	3.78E-03	3.83E-03	3.25E-03	2.55E-03	1.60E-03	1.19E-03	9.41E-04
8.33E-01	8.25E-01	8.17E-01	8.79E-01	9.05E-01	7.92E-01	6.23E-01	3.93E-01	2.51E-01	1.78E-01
1.94E+0	1.92E+0	1.89E+0	2.05E+0	2.12E+0	1.87E+0	1.47E+0	9.27E+0	5.75E+0	4.00E+0
2.12E+0	2.10E+0	2.08E+0	2.25E+0	2.32E+0	2.04E+0	1.61E+0	1.01E+0	6.32E+0	4.41E+0
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-52: Hourly Primary Energy Consumption from NGCC (AC) in May.

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	1.67E+02	1.67E+02	7.40E-02	6.12E-02
Hour 4	1.57E+02	1.57E+02	6.98E-02	5.77E-02
Hour 5	1.50E+02	1.50E+02	6.66E-02	5.51E-02
Hour 6	1.43E+02	1.43E+02	6.34E-02	5.24E-02
Hour 7	1.79E+02	1.79E+02	7.93E-02	6.56E-02
Hour 8	624.1595	623.4083	3.58E-01	3.93E-01
Hour 9	955.6741	954.4234	5.81E-01	6.70E-01
Hour 10	987.9687	986.6391	6.13E-01	7.17E-01
Hour 11	1.08E+03	1.07E+03	6.99E-01	8.44E-01
Hour 12	1.13E+03	1.13E+03	7.53E-01	9.23E-01
Hour 13	1.11E+03	1.10E+03	7.29E-01	8.90E-01
Hour 14	1.10E+03	1.09E+03	7.20E-01	8.75E-01
Hour 15	1.08E+03	1.08E+03	7.08E-01	8.58E-01
Hour 16	1.17E+03	1.17E+03	7.89E-01	9.78E-01
Hour 17	1.20E+03	1.20E+03	8.23E-01	1.03E+00
Hour 18	1.05E+03	1.05E+03	7.40E-01	9.40E-01
Hour 19	828.6188	827.2896	5.85E-01	7.44E-01
Hour 20	522.2081	521.3672	3.70E-01	4.71E-01
Hour 21	332.8727	332.4291	2.05E-01	2.38E-01
Hour 22	236.1488	235.8873	1.28E-01	1.34E-01

Table H-53: Hourly Air Emissions from Average Electric Mix (EC) in May.

Zinc	2.97E-07	2.97E-07	2.97E-07	2.97E-07	2.97E-07	1.04E-06	9.41E-07	9.41E-07	9.41E-07	1.04E-06
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	5.64E-05	5.64E-05	5.64E-05	5.64E-05	5.64E-05	1.97E-04	1.79E-04	1.79E-04	1.79E-04	1.97E-04
VOC	0	0	0	0	0	0	0	0	0	0
Vanadium	2.38E-08	2.38E-08	2.38E-08	2.38E-08	2.38E-08	8.32E-08	7.53E-08	7.53E-08	7.53E-08	8.32E-08
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	3.96E-04	3.58E-04	3.58E-04	3.58E-04	3.96E-04
Selenium	2.46E-10	2.46E-10	2.46E-10	2.46E-10	2.46E-10	8.61E-10	7.79E-10	7.79E-10	7.79E-10	8.61E-10
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	2.16E-08	2.16E-08	2.16E-08	2.16E-08	2.16E-08	7.54E-08	6.83E-08	6.83E-08	6.83E-08	7.54E-08
Molybdenu	1.13E-08	1.13E-08	1.13E-08	1.13E-08	1.13E-08	3.96E-08	3.58E-08	3.58E-08	3.58E-08	3.96E-08
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	2.67E-09	2.67E-09	2.67E-09	2.67E-09	2.67E-09	9.35E-09	8.46E-09	8.46E-09	8.46E-09	9.35E-09
Manganese	3.90E-09	3.90E-09	3.90E-09	3.90E-09	3.90E-09	1.37E-08	1.24E-08	1.24E-08	1.24E-08	1.37E-08
Lead	5.13E-09	5.13E-09	5.13E-09	5.13E-09	5.13E-09	1.79E-08	1.62E-08	1.62E-08	1.62E-08	1.79E-08
HC	0	0	0	0	0	0	0	0	0	0
Copper	8.72E-09	8.72E-09	8.72E-09	8.72E-09	8.72E-09	3.05E-08	2.76E-08	2.76E-08	2.76E-08	3.05E-08
Cobalt	8.62E-10	8.62E-10	8.62E-10	8.62E-10	8.62E-10	3.02E-09	2.73E-09	2.73E-09	2.73E-09	3.02E-09
Chromium	1.43E-08	1.43E-08	1.43E-08	1.43E-08	1.43E-08	5.02E-08	4.54E-08	4.54E-08	4.54E-08	5.02E-08
Cadmium	1.13E-08	1.13E-08	1.13E-08	1.13E-08	1.13E-08	3.96E-08	3.58E-08	3.58E-08	3.58E-08	3.96E-08
Beryllium	1.23E-10	1.23E-10	1.23E-10	1.23E-10	1.23E-10	4.32E-10	3.91E-10	3.91E-10	3.91E-10	4.32E-10
Benzene	0	0	0	0	0	0	0	0	0	0
Barium	4.64E-08	4.64E-08	4.64E-08	4.64E-08	4.64E-08	1.62E-07	1.47E-07	1.47E-07	1.47E-07	1.62E-07
arsenic	2.05E-09	2.05E-09	2.05E-09	2.05E-09	2.05E-09	7.18E-09	6.50E-09	6.50E-09	6.50E-09	7.18E-09
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehyd	0	0	0	0	0	0	0	0	0	0
NH3	1.64E-06	1.55E-06	1.47E-06	1.40E-06	1.77E-06	5.25E-06	7.83E-06	7.97E-06	8.34E-06	8.56E-06
H2S	1.11E-08	1.09E-08	1.07E-08	1.05E-08	1.14E-08	3.78E-08	4.17E-08	4.20E-08	4.29E-08	4.58E-08
NMVOC	1.67E-02	1.57E-02	1.50E-02	1.43E-02	1.80E-02	5.34E-02	7.94E-02	8.08E-02	8.45E-02	8.68E-02
CO	4.33E-02	4.08E-02	3.89E-02	3.70E-02	4.64E-02	1.39E-01	2.05E-01	2.08E-01	2.18E-01	2.24E-01
Particulates	6.45E-03	6.07E-03	5.79E-03	5.50E-03	6.93E-03	2.06E-02	3.06E-02	3.11E-02	3.25E-02	3.34E-02
HF	1.93E-04	1.81E-04	1.73E-04	1.64E-04	2.07E-04	6.16E-04	9.18E-04	9.34E-04	9.77E-04	1.00E-03
HCl	3.88E-03	3.65E-03	3.47E-03	3.30E-03	4.17E-03	1.24E-02	1.85E-02	1.88E-02	1.96E-02	2.02E-02
NOx	1.72E-01	1.62E-01	1.54E-01	1.46E-01	1.85E-01	5.49E-01	8.17E-01	8.31E-01	8.69E-01	8.93E-01
SO2	5.22E-02	4.91E-02	4.67E-02	4.44E-02	5.60E-02	1.66E-01	2.48E-01	2.52E-01	2.64E-01	2.71E-01
SO2 eq.	1.76E-01	1.65E-01	1.57E-01	1.49E-01	1.89E-01	5.60E-01	8.35E-01	8.49E-01	8.88E-01	9.12E-01
TOPP eq.	2.33E-01	2.19E-01	2.09E-01	1.98E-01	2.50E-01	7.44E-01	1.11E+0	1.13E+0	1.18E+0	1.21E+0
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

9.41E-07	9.41E-07	9.41E-07	1.04E-06	1.04E-06	8.42E-07	5.94E-07	3.96E-07	2.97E-07	2.97E-07
0	0	0	0	0	0	0	0	0	0
1.79E-04	1.79E-04	1.79E-04	1.97E-04	1.97E-04	1.60E-04	1.13E-04	7.52E-05	5.64E-05	5.64E-05
0	0	0	0	0	0	0	0	0	0
7.53E-08	7.53E-08	7.53E-08	8.32E-08	8.32E-08	6.74E-08	4.75E-08	3.17E-08	2.38E-08	2.38E-08
0	0	0	0	0	0	0	0	0	0
3.58E-04	3.58E-04	3.58E-04	3.96E-04	3.96E-04	3.20E-04	2.26E-04	1.51E-04	1.13E-04	1.13E-04
7.79E-10	7.79E-10	7.79E-10	8.61E-10	8.61E-10	6.97E-10	4.92E-10	3.28E-10	2.46E-10	2.46E-10
0	0	0	0	0	0	0	0	0	0
6.83E-08	6.83E-08	6.83E-08	7.54E-08	7.54E-08	6.11E-08	4.31E-08	2.87E-08	2.16E-08	2.16E-08
3.58E-08	3.58E-08	3.58E-08	3.96E-08	3.96E-08	3.20E-08	2.26E-08	1.51E-08	1.13E-08	1.13E-08
0	0	0	0	0	0	0	0	0	0
8.46E-09	8.46E-09	8.46E-09	9.35E-09	9.35E-09	7.57E-09	5.34E-09	3.56E-09	2.67E-09	2.67E-09
1.24E-08	1.24E-08	1.24E-08	1.37E-08	1.37E-08	1.11E-08	7.81E-09	5.20E-09	3.90E-09	3.90E-09
1.62E-08	1.62E-08	1.62E-08	1.79E-08	1.79E-08	1.45E-08	1.03E-08	6.84E-09	5.13E-09	5.13E-09
0	0	0	0	0	0	0	0	0	0
2.76E-08	2.76E-08	2.76E-08	3.05E-08	3.05E-08	2.47E-08	1.74E-08	1.16E-08	8.72E-09	8.72E-09
2.73E-09	2.73E-09	2.73E-09	3.02E-09	3.02E-09	2.44E-09	1.72E-09	1.15E-09	8.62E-10	8.62E-10
4.54E-08	4.54E-08	4.54E-08	5.02E-08	5.02E-08	4.06E-08	2.87E-08	1.91E-08	1.43E-08	1.43E-08
3.58E-08	3.58E-08	3.58E-08	3.96E-08	3.96E-08	3.20E-08	2.26E-08	1.51E-08	1.13E-08	1.13E-08
3.91E-10	3.91E-10	3.91E-10	4.32E-10	4.32E-10	3.50E-10	2.47E-10	1.65E-10	1.23E-10	1.23E-10
0	0	0	0	0	0	0	0	0	0
1.47E-07	1.47E-07	1.47E-07	1.62E-07	1.62E-07	1.31E-07	9.27E-08	6.18E-08	4.64E-08	4.64E-08
6.50E-09	6.50E-09	6.50E-09	7.18E-09	7.18E-09	5.81E-09	4.10E-09	2.74E-09	2.05E-09	2.05E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
8.47E-06	8.43E-06	8.38E-06	8.72E-06	8.87E-06	7.56E-06	5.94E-06	3.73E-06	2.71E-06	2.10E-06
4.32E-08	4.31E-08	4.30E-08	4.62E-08	4.66E-08	3.86E-08	2.87E-08	1.86E-08	1.37E-08	1.22E-08
8.58E-02	8.54E-02	8.49E-02	8.84E-02	8.99E-02	7.66E-02	6.02E-02	3.78E-02	2.74E-02	2.13E-02
2.21E-01	2.20E-01	2.19E-01	2.28E-01	2.32E-01	1.97E-01	1.55E-01	9.73E-02	7.06E-02	5.49E-02
3.30E-02	3.29E-02	3.27E-02	3.40E-02	3.46E-02	2.95E-02	2.32E-02	1.45E-02	1.06E-02	8.20E-03
9.92E-04	9.88E-04	9.82E-04	1.02E-03	1.04E-03	8.86E-04	6.96E-04	4.37E-04	3.17E-04	2.46E-04
1.99E-02	1.99E-02	1.97E-02	2.05E-02	2.09E-02	1.78E-02	1.40E-02	8.78E-03	6.38E-03	4.94E-03
8.83E-01	8.79E-01	8.73E-01	9.09E-01	9.24E-01	7.88E-01	6.19E-01	3.89E-01	2.82E-01	2.19E-01
2.68E-01	2.67E-01	2.65E-01	2.76E-01	2.81E-01	2.39E-01	1.88E-01	1.18E-01	8.57E-02	6.64E-02
9.02E-01	8.98E-01	8.92E-01	9.29E-01	9.44E-01	8.05E-01	6.33E-01	3.97E-01	2.88E-01	2.23E-01
1.20E+0	1.19E+0	1.18E+0	1.23E+0	1.25E+0	1.07E+0	8.39E-01	5.27E-01	3.82E-01	2.96E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-54: Hourly GWP Emissions from Average Electric Mix (EC) in May.

Vanadiu	0	0	0	0	0	0	0	0	0	0
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	0	0	0	0	0	0	0	0	0	0
Selenium	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	0	0	0	0	0	0	0	0	0	0
Molybde	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	0	0	0	0	0	0	0	0	0	0
Perfluoro	0	0	0	0	0	0	0	0	0	0
Perfluoro	0	0	0	0	0	0	0	0	0	0
Perfluoro	0	0	0	0	0	0	0	0	0	0
Perfluoro	0	0	0	0	0	0	0	0	0	0
Perfluoro	0	0	0	0	0	0	0	0	0	0
Perfluoro	2.38E-08	2.24E-08	2.13E-08	2.02E-08	2.56E-08	7.60E-08	1.13E-07	1.15E-07	1.21E-07	1.24E-07
Perfluoro	1.89E-07	1.78E-07	1.70E-07	1.61E-07	2.03E-07	6.05E-07	9.02E-07	9.18E-07	9.60E-07	9.86E-07
SF6	0	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0	0
HFC-	0	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0	0
HFC-	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-134	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-125	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-43-	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-32	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-23	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
N2O	2.71E-03	2.55E-03	2.43E-03	2.31E-03	2.91E-03	8.64E-03	1.29E-02	1.31E-02	1.37E-02	1.41E-02
CH4	1.28E-01	1.20E-01	1.15E-01	1.09E-01	1.37E-01	4.09E-01	5.99E-01	6.09E-01	6.36E-01	6.55E-01
CO2	5.07E+0	4.78E+0	4.56E+0	4.34E+0	5.44E+0	1.62E+0	2.39E+0	2.43E+0	2.54E+0	2.62E+0
CO2 eq.	5.42E+0	5.11E+0	4.87E+0	4.64E+0	5.82E+0	1.74E+0	2.56E+0	2.60E+0	2.72E+0	2.80E+0
Option	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1.23E-07	1.22E-07	1.21E-07	1.26E-07	1.28E-07	1.09E-07	8.60E-08	5.40E-08	3.92E-08	3.03E-08
9.75E-07	9.70E-07	9.65E-07	1.00E-06	1.02E-06	8.70E-07	6.84E-07	4.29E-07	3.12E-07	2.41E-07
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
1.39E-02	1.38E-02	1.38E-02	1.43E-02	1.46E-02	1.24E-02	9.77E-03	6.13E-03	4.45E-03	3.45E-03
6.46E-01	6.43E-01	6.39E-01	6.66E-01	6.77E-01	5.77E-01	4.52E-01	2.84E-01	2.06E-01	1.61E-01
2.58E+0	2.57E+0	2.55E+0	2.66E+0	2.71E+0	2.31E+0	1.81E+0	1.14E+0	8.25E+0	6.42E+0
2.76E+0	2.75E+0	2.73E+0	2.85E+0	2.89E+0	2.46E+0	1.93E+0	1.21E+0	8.82E+0	6.87E+0
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-55: Hourly Primary Energy Consumption from Average Electric Mix (EC) in May.

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.14E+02	1.94E+02	6.57E+00	1.33E+01
Hour 4	2.02E+02	1.83E+02	6.18E+00	1.25E+01
Hour 5	1.93E+02	1.75E+02	5.89E+00	1.19E+01
Hour 6	1.83E+02	1.67E+02	5.59E+00	1.13E+01
Hour 7	2.30E+02	2.08E+02	7.06E+00	1.43E+01
Hour 8	6.87E+02	6.23E+02	2.10E+01	4.24E+01
Hour 9	1.01E+03	9.15E+02	3.13E+01	6.32E+01
Hour 10	1.03E+03	9.30E+02	3.18E+01	6.43E+01
Hour 11	1.07E+03	9.72E+02	3.33E+01	6.73E+01
Hour 12	1.10E+03	1.00E+03	3.42E+01	6.91E+01
Hour 13	1.09E+03	9.87E+02	3.38E+01	6.83E+01
Hour 14	1.08E+03	9.82E+02	3.37E+01	6.80E+01
Hour 15	1.08E+03	9.76E+02	3.35E+01	6.76E+01
Hour 16	1.12E+03	1.02E+03	3.48E+01	7.04E+01
Hour 17	1.14E+03	1.03E+03	3.54E+01	7.16E+01
Hour 18	9.72E+02	8.81E+02	3.02E+01	6.10E+01
Hour 19	7.63E+02	6.91E+02	2.37E+01	4.80E+01
Hour 20	4.79E+02	4.34E+02	1.49E+01	3.01E+01
Hour 21	3.48E+02	3.15E+02	1.08E+01	2.19E+01
Hour 22	2.71E+02	2.46E+02	8.38E+00	1.69E+01

Table H-56: Hourly Air Emissions from Average Electric Mix (AC) in May.

Zinc	2.97E-07	2.83E-07	2.97E-07	2.97E-07	2.97E-07	6.98E-06	1.24E-05	1.37E-05	1.72E-05	1.94E-05
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	5.64E-05	5.37E-05	5.64E-05	5.64E-05	5.64E-05	1.33E-03	2.36E-03	2.60E-03	3.26E-03	3.68E-03
VOC	0	0	0	0	0	0	0	0	0	0
Vanadium	2.38E-08	2.26E-08	2.38E-08	2.38E-08	2.38E-08	5.59E-07	9.96E-07	1.10E-06	1.37E-06	1.55E-06
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	1.13E-04	1.08E-04	1.13E-04	1.13E-04	1.13E-04	2.66E-03	4.73E-03	5.22E-03	6.53E-03	7.37E-03
Selenium	2.46E-10	2.34E-10	2.46E-10	2.46E-10	2.46E-10	5.78E-09	1.03E-08	1.14E-08	1.42E-08	1.60E-08
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	2.16E-08	2.05E-08	2.16E-08	2.16E-08	2.16E-08	5.06E-07	9.03E-07	9.95E-07	1.25E-06	1.41E-06
Molybdenu	1.13E-08	1.08E-08	1.13E-08	1.13E-08	1.13E-08	2.66E-07	4.73E-07	5.22E-07	6.53E-07	7.37E-07
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	2.67E-09	2.54E-09	2.67E-09	2.67E-09	2.67E-09	6.28E-08	1.12E-07	1.23E-07	1.54E-07	1.74E-07
Manganese	3.90E-09	3.72E-09	3.90E-09	3.90E-09	3.90E-09	9.17E-08	1.64E-07	1.80E-07	2.25E-07	2.55E-07
Lead	5.13E-09	4.88E-09	5.13E-09	5.13E-09	5.13E-09	1.21E-07	2.15E-07	2.37E-07	2.96E-07	3.35E-07
HC	0	0	0	0	0	0	0	0	0	0
Copper	8.72E-09	8.30E-09	8.72E-09	8.72E-09	8.72E-09	2.05E-07	3.65E-07	4.03E-07	5.04E-07	5.69E-07
Cobalt	8.62E-10	8.21E-10	8.62E-10	8.62E-10	8.62E-10	2.03E-08	3.61E-08	3.98E-08	4.98E-08	5.63E-08
Chromium	1.43E-08	1.37E-08	1.43E-08	1.43E-08	1.43E-08	3.37E-07	6.01E-07	6.62E-07	8.28E-07	9.35E-07
Cadmium	1.13E-08	1.08E-08	1.13E-08	1.13E-08	1.13E-08	2.66E-07	4.73E-07	5.22E-07	6.53E-07	7.37E-07
Beryllium	1.23E-10	1.18E-10	1.23E-10	1.23E-10	1.23E-10	2.90E-09	5.17E-09	5.70E-09	7.13E-09	8.06E-09
Benzene	0	0	0	0	0	0	0	0	0	0
Barium	4.64E-08	4.42E-08	4.64E-08	4.64E-08	4.64E-08	1.09E-06	1.94E-06	2.14E-06	2.68E-06	3.03E-06
arsenic	2.05E-09	1.95E-09	2.05E-09	2.05E-09	2.05E-09	4.82E-08	8.59E-08	9.47E-08	1.19E-07	1.34E-07
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehyd	0	0	0	0	0	0	0	0	0	0
NH3	1.64E-06	1.55E-06	1.47E-06	1.40E-06	1.77E-06	4.63E-06	6.64E-06	6.65E-06	6.66E-06	6.67E-06
H2S	1.11E-08	1.06E-08	1.07E-08	1.05E-08	1.14E-08	1.79E-07	3.15E-07	3.46E-07	4.28E-07	4.82E-07
NMVOC	1.67E-02	1.57E-02	1.50E-02	1.43E-02	1.80E-02	5.01E-02	7.30E-02	7.37E-02	7.55E-02	7.66E-02
CO	4.33E-02	4.07E-02	3.89E-02	3.70E-02	4.64E-02	1.44E-01	2.15E-01	2.20E-01	2.32E-01	2.40E-01
Particulates	6.45E-03	6.07E-03	5.79E-03	5.50E-03	6.93E-03	2.02E-02	2.98E-02	3.02E-02	3.14E-02	3.22E-02
HF	1.93E-04	1.82E-04	1.73E-04	1.64E-04	2.07E-04	5.52E-04	7.94E-04	7.96E-04	8.02E-04	8.06E-04
HCl	3.88E-03	3.65E-03	3.47E-03	3.30E-03	4.17E-03	1.10E-02	1.58E-02	1.58E-02	1.59E-02	1.60E-02
NOx	1.72E-01	1.62E-01	1.54E-01	1.46E-01	1.85E-01	5.01E-01	7.24E-01	7.28E-01	7.39E-01	7.45E-01
SO2	5.22E-02	4.91E-02	4.67E-02	4.44E-02	5.60E-02	1.49E-01	2.15E-01	2.16E-01	2.17E-01	2.18E-01
So2 EQ.	1.76E-01	1.65E-01	1.57E-01	1.49E-01	1.89E-01	5.09E-01	7.34E-01	7.38E-01	7.47E-01	7.53E-01
Top EQ.	2.33E-01	2.19E-01	2.09E-01	1.98E-01	2.50E-01	6.84E-01	9.90E-01	9.97E-01	1.01E+0	1.02E+0
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

1.84E-05	1.80E-05	1.75E-05	2.09E-05	2.22E-05	2.08E-05	1.65E-05	1.05E-05	4.50E-06	2.00E-06
0	0	0	0	0	0	0	0	0	0
3.49E-03	3.42E-03	3.33E-03	3.96E-03	4.22E-03	3.96E-03	3.13E-03	1.99E-03	8.53E-04	3.79E-04
0	0	0	0	0	0	0	0	0	0
1.47E-06	1.44E-06	1.40E-06	1.67E-06	1.78E-06	1.67E-06	1.32E-06	8.39E-07	3.60E-07	1.60E-07
0	0	0	0	0	0	0	0	0	0
7.00E-03	6.85E-03	6.67E-03	7.93E-03	8.45E-03	7.93E-03	6.27E-03	3.99E-03	1.71E-03	7.59E-04
1.52E-08	1.49E-08	1.45E-08	1.73E-08	1.84E-08	1.72E-08	1.36E-08	8.68E-09	3.72E-09	1.65E-09
0	0	0	0	0	0	0	0	0	0
1.33E-06	1.31E-06	1.27E-06	1.51E-06	1.61E-06	1.51E-06	1.20E-06	7.61E-07	3.26E-07	1.45E-07
7.00E-07	6.85E-07	6.67E-07	7.93E-07	8.45E-07	7.93E-07	6.27E-07	3.99E-07	1.71E-07	7.59E-08
0	0	0	0	0	0	0	0	0	0
1.65E-07	1.62E-07	1.58E-07	1.87E-07	2.00E-07	1.87E-07	1.48E-07	9.43E-08	4.04E-08	1.79E-08
2.42E-07	2.37E-07	2.30E-07	2.74E-07	2.92E-07	2.74E-07	2.17E-07	1.38E-07	5.90E-08	2.62E-08
3.17E-07	3.11E-07	3.03E-07	3.60E-07	3.83E-07	3.60E-07	2.85E-07	1.81E-07	7.76E-08	3.44E-08
0	0	0	0	0	0	0	0	0	0
5.40E-07	5.28E-07	5.15E-07	6.12E-07	6.52E-07	6.11E-07	4.84E-07	3.08E-07	1.32E-07	5.85E-08
5.34E-08	5.23E-08	5.09E-08	6.05E-08	6.45E-08	6.05E-08	4.79E-08	3.04E-08	1.30E-08	5.79E-09
8.87E-07	8.69E-07	8.46E-07	1.01E-06	1.07E-06	1.01E-06	7.96E-07	5.06E-07	2.17E-07	9.63E-08
7.00E-07	6.85E-07	6.67E-07	7.93E-07	8.45E-07	7.93E-07	6.27E-07	3.99E-07	1.71E-07	7.59E-08
7.64E-09	7.49E-09	7.29E-09	8.66E-09	9.23E-09	8.66E-09	6.85E-09	4.36E-09	1.87E-09	8.29E-10
0	0	0	0	0	0	0	0	0	0
2.87E-06	2.81E-06	2.74E-06	3.25E-06	3.47E-06	3.25E-06	2.57E-06	1.64E-06	7.01E-07	3.11E-07
1.27E-07	1.24E-07	1.21E-07	1.44E-07	1.53E-07	1.44E-07	1.14E-07	7.24E-08	3.10E-08	1.38E-08
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
6.66E-06	6.66E-06	6.66E-06	6.68E-06	6.69E-06	5.50E-06	4.31E-06	2.69E-06	2.27E-06	1.92E-06
4.58E-07	4.49E-07	4.37E-07	5.17E-07	5.50E-07	5.14E-07	4.06E-07	2.58E-07	1.13E-07	5.26E-08
7.61E-02	7.59E-02	7.57E-02	7.74E-02	7.81E-02	6.55E-02	5.14E-02	3.22E-02	2.51E-02	2.03E-02
2.37E-01	2.35E-01	2.33E-01	2.46E-01	2.50E-01	2.15E-01	1.69E-01	1.06E-01	7.44E-02	5.64E-02
3.18E-02	3.17E-02	3.16E-02	3.27E-02	3.32E-02	2.81E-02	2.21E-02	1.39E-02	1.03E-02	8.08E-03
8.04E-04	8.04E-04	8.03E-04	8.08E-04	8.11E-04	6.70E-04	5.25E-04	3.28E-04	2.72E-04	2.28E-04
1.59E-02	1.59E-02	1.59E-02	1.60E-02	1.60E-02	1.32E-02	1.03E-02	6.46E-03	5.41E-03	4.55E-03
7.42E-01	7.41E-01	7.40E-01	7.50E-01	7.54E-01	6.27E-01	4.92E-01	3.07E-01	2.48E-01	2.05E-01
2.18E-01	2.18E-01	2.17E-01	2.19E-01	2.20E-01	1.82E-01	1.42E-01	8.90E-02	7.36E-02	6.15E-02
7.50E-01	7.49E-01	7.48E-01	7.56E-01	7.60E-01	6.31E-01	4.95E-01	3.09E-01	2.52E-01	2.09E-01
1.02E+0	1.02E+0	1.02E+0	1.03E+0	1.04E+0	8.65E-01	6.78E-01	4.24E-01	3.40E-01	2.79E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-57: Hourly GWP Emissions from Average Electric Mix (AC) in May.

Perfluoropen	0	0	0	0	0	0	0	0	0	0
Perfluorobut	0	0	0	0	0	0	0	0	0	0
Perfluoropro	0	0	0	0	0	0	0	0	0	0
Perfluorohex	0	0	0	0	0	0	0	0	0	0
Perfluorocyc	0	0	0	0	0	0	0	0	0	0
Perfluoroeth	2.38E-08	2.24E-08	2.13E-08	2.02E-08	2.56E-08	6.72E-08	9.63E-08	9.64E-08	9.66E-08	9.68E-08
Perfluoromet	1.89E-07	1.78E-07	1.70E-07	1.61E-07	2.03E-07	5.35E-07	7.66E-07	7.67E-07	7.69E-07	7.70E-07
SF6	0	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0	0
HFC-43-	0	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0	0
HFC-23	0	0	0	0	0	0	0	0	0	0
N2O	2.71E-03	2.55E-03	2.43E-03	2.31E-03	2.91E-03	7.83E-03	1.13E-02	1.14E-02	1.15E-02	1.16E-02
CH4	1.28E-01	1.20E-01	1.15E-01	1.09E-01	1.37E-01	4.74E-01	7.25E-01	7.49E-01	8.14E-01	8.56E-01
CO2	5.07E+0	4.77E+0	4.56E+0	4.34E+0	5.44E+0	1.72E+0	2.58E+0	2.64E+0	2.81E+0	2.91E+0
CO2 eq.	5.42E+0	5.10E+0	4.87E+0	4.64E+0	5.82E+0	1.84E+0	2.77E+0	2.83E+0	3.01E+0	3.13E+0
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
9.67E-08	9.67E-08	9.67E-08	9.69E-08	9.70E-08	7.99E-08	6.25E-08	3.90E-08	3.30E-08	2.78E-08
7.70E-07	7.69E-07	7.69E-07	7.71E-07	7.72E-07	6.35E-07	4.98E-07	3.11E-07	2.62E-07	2.21E-07
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1.15E-02	1.15E-02	1.15E-02	1.16E-02	1.17E-02	9.69E-03	7.59E-03	4.75E-03	3.88E-03	3.22E-03
8.37E-01	8.30E-01	8.21E-01	8.84E-01	9.09E-01	7.96E-01	6.26E-01	3.95E-01	2.52E-01	1.80E-01
2.87E+02	2.85E+02	2.83E+02	2.99E+02	3.05E+02	2.63E+02	2.07E+02	1.30E+02	8.94E+01	6.70E+01
3.08E+02	3.06E+02	3.03E+02	3.21E+02	327.8768	2.83E+02	2.22E+02	1.40E+02	9.59E+01	7.18E+01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-58: Hourly Primary Energy Consumption from Average Electric Mix (AC) in May.

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.14E+02	1.94E+02	6.57E+00	1.33E+01
Hour 4	2.02E+02	1.83E+02	6.19E+00	1.25E+01
Hour 5	1.93E+02	1.75E+02	5.89E+00	1.19E+01
Hour 6	1.83E+02	1.67E+02	5.59E+00	1.13E+01
Hour 7	229.7482	208.4105	7.06E+00	1.43E+01
Hour 8	757.0349	700.9552	1.86E+01	3.75E+01
Hour 9	1.15E+03	1.07E+03	2.67E+01	5.37E+01
Hour 10	1.18E+03	1.10E+03	2.67E+01	5.38E+01
Hour 11	1.27E+03	1.18E+03	2.68E+01	5.39E+01
Hour 12	1.32E+03	1.24E+03	2.69E+01	5.40E+01
Hour 13	1.30E+03	1.22E+03	2.68E+01	5.39E+01
Hour 14	1.29E+03	1.21E+03	2.68E+01	5.39E+01
Hour 15	1.27E+03	1.19E+03	2.68E+01	5.39E+01
Hour 16	1.36E+03	1.28E+03	2.69E+01	5.40E+01
Hour 17	1.39E+03	1.31E+03	2.69E+01	5.41E+01
Hour 18	1.21E+03	1.14E+03	2.22E+01	4.45E+01
Hour 19	951.7245	899.4955	1.74E+01	3.49E+01
Hour 20	599.0905	566.4742	1.08E+01	2.18E+01
Hour 21	397.8615	370.3442	9.13E+00	1.84E+01
Hour 22	291.2967	268.0785	7.70E+00	1.55E+01

Table H-59: Hourly Air Emissions from NGCC (EC) in August.

Zinc	2.97E-07	2.97E-07	2.97E-07	2.97E-07	2.97E-07	1.04E-06	9.41E-07	9.41E-07	9.41E-07	1.04E-06
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	5.64E-05	5.64E-05	5.64E-05	5.64E-05	5.64E-05	1.97E-04	1.79E-04	1.79E-04	1.79E-04	1.97E-04
VOC	0	0	0	0	0	0	0	0	0	0
Vanadium	2.38E-08	2.38E-08	2.38E-08	2.38E-08	2.38E-08	8.32E-08	7.53E-08	7.53E-08	7.53E-08	8.32E-08
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	3.96E-04	3.58E-04	3.58E-04	3.58E-04	3.96E-04
Selenium	2.46E-10	2.46E-10	2.46E-10	2.46E-10	2.46E-10	8.61E-10	7.79E-10	7.79E-10	7.79E-10	8.61E-10
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	2.16E-08	2.16E-08	2.16E-08	2.16E-08	2.16E-08	7.54E-08	6.83E-08	6.83E-08	6.83E-08	7.54E-08
Molybdenu	1.13E-08	1.13E-08	1.13E-08	1.13E-08	1.13E-08	3.96E-08	3.58E-08	3.58E-08	3.58E-08	3.96E-08
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	2.67E-09	2.67E-09	2.67E-09	2.67E-09	2.67E-09	9.35E-09	8.46E-09	8.46E-09	8.46E-09	9.35E-09
Manganese	3.90E-09	3.90E-09	3.90E-09	3.90E-09	3.90E-09	1.37E-08	1.24E-08	1.24E-08	1.24E-08	1.37E-08
Lead	5.13E-09	5.13E-09	5.13E-09	5.13E-09	5.13E-09	1.79E-08	1.62E-08	1.62E-08	1.62E-08	1.79E-08
HC	0	0	0	0	0	0	0	0	0	0
Copper	8.72E-09	8.72E-09	8.72E-09	8.72E-09	8.72E-09	3.05E-08	2.76E-08	2.76E-08	2.76E-08	3.05E-08
Cobalt	8.62E-10	8.62E-10	8.62E-10	8.62E-10	8.62E-10	3.02E-09	2.73E-09	2.73E-09	2.73E-09	3.02E-09
Chromium	1.43E-08	1.43E-08	1.43E-08	1.43E-08	1.43E-08	5.02E-08	4.54E-08	4.54E-08	4.54E-08	5.02E-08
Cadmium	1.13E-08	1.13E-08	1.13E-08	1.13E-08	1.13E-08	3.96E-08	3.58E-08	3.58E-08	3.58E-08	3.96E-08
Beryllium	1.23E-10	1.23E-10	1.23E-10	1.23E-10	1.23E-10	4.32E-10	3.91E-10	3.91E-10	3.91E-10	4.32E-10
Benzene	5.95E-06	5.75E-06	5.52E-06	5.26E-06	6.65E-06	1.69E-05	2.36E-05	2.51E-05	2.47E-05	2.61E-05
Barium	4.64E-08	4.64E-08	4.64E-08	4.64E-08	4.64E-08	1.62E-07	1.47E-07	1.47E-07	1.47E-07	1.62E-07
arsenic	2.05E-09	2.05E-09	2.05E-09	2.05E-09	2.05E-09	7.18E-09	6.50E-09	6.50E-09	6.50E-09	7.18E-09
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehyd	0	0	0	0	0	0	0	0	0	0
NH3	1.01E-08	9.76E-09	9.42E-09	8.99E-09	1.13E-08	2.90E-08	3.99E-08	4.27E-08	4.20E-08	4.47E-08
H2S	2.00E-07	1.94E-07	1.86E-07	1.78E-07	2.23E-07	5.73E-07	7.86E-07	8.37E-07	8.25E-07	8.72E-07
NMVOC	1.31E-03	1.27E-03	1.22E-03	1.17E-03	1.44E-03	3.81E-03	5.06E-03	5.36E-03	5.29E-03	5.61E-03
CO	2.97E-02	2.88E-02	2.76E-02	2.64E-02	3.31E-02	8.51E-02	1.17E-01	1.24E-01	1.23E-01	1.30E-01
Particulates	2.54E-03	2.46E-03	2.36E-03	2.25E-03	2.82E-03	7.27E-03	9.96E-03	1.06E-02	1.05E-02	1.11E-02
HF	1.08E-05	1.05E-05	1.01E-05	9.63E-06	1.21E-05	3.11E-05	4.26E-05	4.54E-05	4.47E-05	4.73E-05
HCl	1.06E-04	1.02E-04	9.84E-05	9.40E-05	1.18E-04	3.03E-04	4.16E-04	4.43E-04	4.36E-04	4.61E-04
NOx	9.90E-02	9.58E-02	9.19E-02	8.76E-02	1.11E-01	2.82E-01	3.91E-01	4.17E-01	4.11E-01	4.34E-01
SO2	3.93E-03	3.81E-03	3.65E-03	3.49E-03	4.38E-03	1.12E-02	1.55E-02	1.65E-02	1.62E-02	1.72E-02
SO2 eq.	7.30E-02	7.06E-02	6.77E-02	6.46E-02	8.15E-02	2.08E-01	2.88E-01	3.07E-01	3.03E-01	3.20E-01
TOPP eq.	1.28E-01	1.23E-01	1.18E-01	1.13E-01	1.42E-01	3.63E-01	5.04E-01	5.37E-01	5.29E-01	5.59E-01
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

9.41E-07	9.41E-07	9.41E-07	1.04E-06	1.04E-06	8.42E-07	5.94E-07	3.96E-07	2.97E-07	2.97E-07
0	0	0	0	0	0	0	0	0	0
1.79E-04	1.79E-04	1.79E-04	1.97E-04	1.97E-04	1.60E-04	1.13E-04	7.52E-05	5.64E-05	5.64E-05
0	0	0	0	0	0	0	0	0	0
7.53E-08	7.53E-08	7.53E-08	8.32E-08	8.32E-08	6.74E-08	4.75E-08	3.17E-08	2.38E-08	2.38E-08
0	0	0	0	0	0	0	0	0	0
3.58E-04	3.58E-04	3.58E-04	3.96E-04	3.96E-04	3.20E-04	2.26E-04	1.51E-04	1.13E-04	1.13E-04
7.79E-10	7.79E-10	7.79E-10	8.61E-10	8.61E-10	6.97E-10	4.92E-10	3.28E-10	2.46E-10	2.46E-10
0	0	0	0	0	0	0	0	0	0
6.83E-08	6.83E-08	6.83E-08	7.54E-08	7.54E-08	6.11E-08	4.31E-08	2.87E-08	2.16E-08	2.16E-08
3.58E-08	3.58E-08	3.58E-08	3.96E-08	3.96E-08	3.20E-08	2.26E-08	1.51E-08	1.13E-08	1.13E-08
0	0	0	0	0	0	0	0	0	0
8.46E-09	8.46E-09	8.46E-09	9.35E-09	9.35E-09	7.57E-09	5.34E-09	3.56E-09	2.67E-09	2.67E-09
1.24E-08	1.24E-08	1.24E-08	1.37E-08	1.37E-08	1.11E-08	7.81E-09	5.20E-09	3.90E-09	3.90E-09
1.62E-08	1.62E-08	1.62E-08	1.79E-08	1.79E-08	1.45E-08	1.03E-08	6.84E-09	5.13E-09	5.13E-09
0	0	0	0	0	0	0	0	0	0
2.76E-08	2.76E-08	2.76E-08	3.05E-08	3.05E-08	2.47E-08	1.74E-08	1.16E-08	8.72E-09	8.72E-09
2.73E-09	2.73E-09	2.73E-09	3.02E-09	3.02E-09	2.44E-09	1.72E-09	1.15E-09	8.62E-10	8.62E-10
4.54E-08	4.54E-08	4.54E-08	5.02E-08	5.02E-08	4.06E-08	2.87E-08	1.91E-08	1.43E-08	1.43E-08
3.58E-08	3.58E-08	3.58E-08	3.96E-08	3.96E-08	3.20E-08	2.26E-08	1.51E-08	1.13E-08	1.13E-08
3.91E-10	3.91E-10	3.91E-10	4.32E-10	4.32E-10	3.50E-10	2.47E-10	1.65E-10	1.23E-10	1.23E-10
2.82E-05	2.86E-05	2.79E-05	3.00E-05	2.98E-05	2.43E-05	1.79E-05	1.21E-05	8.90E-06	7.24E-06
1.47E-07	1.47E-07	1.47E-07	1.62E-07	1.62E-07	1.31E-07	9.27E-08	6.18E-08	4.64E-08	4.64E-08
6.50E-09	6.50E-09	6.50E-09	7.18E-09	7.18E-09	5.81E-09	4.10E-09	2.74E-09	2.05E-09	2.05E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4.88E-08	4.96E-08	4.81E-08	5.23E-08	5.19E-08	4.23E-08	3.08E-08	2.10E-08	1.51E-08	1.23E-08
9.38E-07	9.51E-07	9.29E-07	9.99E-07	9.91E-07	8.08E-07	5.94E-07	4.02E-07	2.96E-07	2.42E-07
5.97E-03	6.05E-03	5.92E-03	6.37E-03	6.33E-03	5.16E-03	3.78E-03	2.56E-03	1.88E-03	1.56E-03
1.40E-01	1.41E-01	1.38E-01	1.49E-01	1.48E-01	1.20E-01	8.84E-02	5.98E-02	4.39E-02	3.59E-02
1.19E-02	1.21E-02	1.18E-02	1.27E-02	1.26E-02	1.03E-02	7.54E-03	5.10E-03	3.75E-03	3.06E-03
5.09E-05	5.16E-05	5.04E-05	5.42E-05	5.37E-05	4.38E-05	3.22E-05	2.18E-05	1.60E-05	1.31E-05
4.96E-04	5.03E-04	4.91E-04	5.28E-04	5.24E-04	4.28E-04	3.14E-04	2.13E-04	1.56E-04	1.28E-04
4.68E-01	4.75E-01	4.64E-01	4.98E-01	4.95E-01	4.03E-01	2.97E-01	2.01E-01	1.48E-01	1.20E-01
1.85E-02	1.88E-02	1.83E-02	1.97E-02	1.96E-02	1.60E-02	1.17E-02	7.93E-03	5.83E-03	4.76E-03
3.45E-01	3.50E-01	3.42E-01	3.67E-01	3.64E-01	2.97E-01	2.19E-01	1.48E-01	1.09E-01	8.86E-02
6.03E-01	6.12E-01	5.97E-01	6.42E-01	6.37E-01	5.19E-01	3.82E-01	2.58E-01	1.90E-01	1.55E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-60: Hourly GWP Emissions from NGCC (EC) in August.

Perfluoropen	0	0	0	0	0	0	0	0	0	0
Perfluorobut	0	0	0	0	0	0	0	0	0	0
Perfluoropro	0	0	0	0	0	0	0	0	0	0
Perfluorohex	0	0	0	0	0	0	0	0	0	0
Perfluorocyc	0	0	0	0	0	0	0	0	0	0
Perfluoroeth	1.83E-10	1.77E-10	1.71E-10	1.63E-10	2.05E-10	5.27E-10	7.22E-10	7.75E-10	7.62E-10	8.11E-10
Perfluoromet	1.46E-09	1.41E-09	1.36E-09	1.30E-09	1.63E-09	4.20E-09	5.74E-09	6.17E-09	6.07E-09	6.45E-09
SF6	0	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0	0
HFC-43-	0	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0	0
HFC-23	0	0	0	0	0	0	0	0	0	0
N2O	9.45148E	9.14229E	8.77043E	8.36431E	1.05545E	2.69026E	3.73269E	3.97743E	3.91927E	4.13815E
CH4	1.57343E	1.52326E	1.46292E	1.39702E	1.75244E	4.50468E	6.18297E	6.58030E	6.48588E	6.85445E
CO2	3.42236E	3.31390E	3.18345E	3.04097E	3.80937E	9.81116E	1.34327E	1.42916E	1.40875E	1.48912E
CO2	3.78208E	3.66212E	3.51786E	3.36028E	4.21010E	1.08405E	1.48469E	1.57968E	1.55711E	1.64589E
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
8.81E-10	8.94E-10	8.71E-10	9.44E-10	9.36E-10	7.63E-10	5.57E-10	3.79E-10	2.74E-10	2.23E-10
7.01E-09	7.12E-09	6.93E-09	7.51E-09	7.45E-09	6.07E-09	4.43E-09	3.02E-09	2.18E-09	1.77E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4.46693E-02	4.52993E-02	4.42330E-02	4.75366E-02	4.71731E-02	3.84784E-02	2.83137E-02	1.91393E-02	1.40817E-02	1.14737E-02
7.37495E-01	7.47723E-01	7.30414E-01	7.85367E-01	7.79466E-01	6.35712E-01	4.67432E-01	3.15903E-01	2.32489E-01	1.90162E-01
1.60094E+02	1.62306E+02	1.58564E+02	1.70512E+02	1.69236E+02	1.38020E+02	1.01468E+02	6.85707E+01	5.04693E+01	4.13188E+01
1.76967E+02	1.79412E+02	1.75274E+02	1.88478E+02	1.87068E+02	1.52563E+02	1.12162E+02	7.57980E+01	5.57881E+01	4.56679E+01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-61: Hourly Primary Energy Consumption from NGCC (EC) in August.

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	208	2.08E+02	9.22E-02	7.82E-02
Hour 4	201	2.01E+02	8.93E-02	7.58E-02
Hour 5	193	1.93E+02	8.58E-02	7.30E-02
Hour 6	184	1.84E+02	8.19E-02	6.97E-02
Hour 7	231	2.31E+02	1.03E-01	8.74E-02
Hour 8	595	5.94E+02	2.64E-01	2.25E-01
Hour 9	816	8.16E+02	3.62E-01	3.09E-01
Hour 10	869	8.68E+02	3.86E-01	3.31E-01
Hour 11	856	8.56E+02	3.80E-01	3.26E-01
Hour 12	905	9.04E+02	4.02E-01	3.47E-01
Hour 13	974	9.73E+02	4.33E-01	3.76E-01
Hour 14	987	9.86E+02	4.39E-01	3.82E-01
Hour 15	964	9.64E+02	4.28E-01	3.72E-01
Hour 16	1,037	1.04E+03	4.61E-01	4.03E-01
Hour 17	1,029	1.03E+03	4.57E-01	4.00E-01
Hour 18	839	8.39E+02	3.73E-01	3.26E-01
Hour 19	617	6.17E+02	2.74E-01	2.38E-01
Hour 20	417	4.17E+02	1.85E-01	1.62E-01
Hour 21	307	3.07E+02	1.36E-01	1.17E-01
Hour 22	251	2.51E+02	1.11E-01	9.52E-02

Table H-62: Hourly Air Emissions from NGCC (AC) in August.

Zinc	3.36E-06	3.41E-06	3.55E-06	3.41E-06	4.21E-06	1.21E-05	1.48E-05	1.96E-05	1.84E-05	2.27E-05
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	6.38E-04	6.47E-04	6.74E-04	6.47E-04	8.00E-04	2.29E-03	2.81E-03	3.72E-03	3.50E-03	4.32E-03
VOC	0	0	0	0	0	0	0	0	0	0
Vanadium	2.69E-07	2.73E-07	2.84E-07	2.73E-07	3.37E-07	9.66E-07	1.18E-06	1.57E-06	1.48E-06	1.82E-06
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	1.28E-03	1.30E-03	1.35E-03	1.30E-03	1.60E-03	4.59E-03	5.63E-03	7.44E-03	7.01E-03	8.65E-03
Selenium	2.78E-09	2.82E-09	2.94E-09	2.82E-09	3.49E-09	9.99E-09	1.23E-08	1.62E-08	1.53E-08	1.88E-08
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	2.44E-07	2.47E-07	2.58E-07	2.47E-07	3.06E-07	8.76E-07	1.07E-06	1.42E-06	1.34E-06	1.65E-06
Molybdenu	1.28E-07	1.30E-07	1.35E-07	1.30E-07	1.60E-07	4.59E-07	5.63E-07	7.44E-07	7.01E-07	8.65E-07
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	3.02E-08	3.07E-08	3.19E-08	3.07E-08	3.79E-08	1.09E-07	1.33E-07	1.76E-07	1.66E-07	2.04E-07
Manganese	4.42E-08	4.48E-08	4.66E-08	4.48E-08	5.53E-08	1.59E-07	1.94E-07	2.57E-07	2.42E-07	2.99E-07
Lead	5.80E-08	5.88E-08	6.13E-08	5.88E-08	7.27E-08	2.08E-07	2.56E-07	3.38E-07	3.18E-07	3.92E-07
HC	0	0	0	0	0	0	0	0	0	0
Copper	9.87E-08	1.00E-07	1.04E-07	1.00E-07	1.24E-07	3.54E-07	4.34E-07	5.74E-07	5.41E-07	6.67E-07
Cobalt	9.76E-09	9.90E-09	1.03E-08	9.90E-09	1.22E-08	3.50E-08	4.30E-08	5.68E-08	5.35E-08	6.60E-08
Chromium	1.62E-07	1.65E-07	1.71E-07	1.65E-07	2.03E-07	5.83E-07	7.14E-07	9.44E-07	8.90E-07	1.10E-06
Cadmium	1.28E-07	1.30E-07	1.35E-07	1.30E-07	1.60E-07	4.59E-07	5.63E-07	7.44E-07	7.01E-07	8.65E-07
Beryllium	1.40E-09	1.42E-09	1.48E-09	1.42E-09	1.75E-09	5.02E-09	6.15E-09	8.13E-09	7.66E-09	9.45E-09
Benzene	4.95E-06	4.74E-06	4.45E-06	4.24E-06	5.37E-06	1.33E-05	1.90E-05	1.90E-05	1.90E-05	1.90E-05
Barium	5.25E-07	5.32E-07	5.54E-07	5.32E-07	6.57E-07	1.88E-06	2.31E-06	3.05E-06	2.88E-06	3.55E-06
arsenic	2.32E-08	2.35E-08	2.45E-08	2.35E-08	2.91E-08	8.34E-08	1.02E-07	1.35E-07	1.27E-07	1.57E-07
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehyd	0	0	0	0	0	0	0	0	0	0
NH3	2.21E-08	2.20E-08	2.22E-08	2.12E-08	2.67E-08	7.24E-08	9.43E-08	1.16E-07	1.11E-07	1.30E-07
H2S	2.41E-07	2.36E-07	2.30E-07	2.19E-07	2.75E-07	7.21E-07	9.72E-07	1.09E-06	1.06E-06	1.16E-06
NMVOC	2.70E-03	2.68E-03	2.70E-03	2.58E-03	3.22E-03	8.82E-03	1.14E-02	1.38E-02	1.32E-02	1.55E-02
CO	3.60E-02	3.52E-02	3.43E-02	3.28E-02	4.12E-02	1.08E-01	1.45E-01	1.63E-01	1.59E-01	1.74E-01
Particulates	3.18E-03	3.11E-03	3.04E-03	2.91E-03	3.65E-03	9.59E-03	1.29E-02	1.45E-02	1.41E-02	1.56E-02
HF	1.43E-05	1.40E-05	1.37E-05	1.31E-05	1.65E-05	4.35E-05	5.82E-05	6.63E-05	6.44E-05	7.17E-05
HCl	1.53E-04	1.50E-04	1.48E-04	1.41E-04	1.78E-04	4.72E-04	6.28E-04	7.27E-04	7.03E-04	7.92E-04
NOx	9.18E-02	8.84E-02	8.42E-02	8.03E-02	1.01E-01	2.56E-01	3.59E-01	3.73E-01	3.70E-01	3.83E-01
SO2	4.79E-03	4.68E-03	4.56E-03	4.36E-03	5.48E-03	1.43E-02	1.94E-02	2.17E-02	2.11E-02	2.32E-02
SO2 eq.	6.89E-02	6.64E-02	6.33E-02	6.04E-02	7.62E-02	1.93E-01	2.70E-01	2.82E-01	2.79E-01	2.90E-01
TOPP eq.	1.21E-01	1.17E-01	1.12E-01	1.07E-01	1.34E-01	3.41E-01	4.75E-01	4.99E-01	4.93E-01	5.14E-01
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

2.91E-05	3.03E-05	2.83E-05	3.47E-05	3.40E-05	2.74E-05	1.79E-05	1.36E-05	7.18E-06	4.92E-06
0	0	0	0	0	0	0	0	0	0
5.52E-03	5.76E-03	5.36E-03	6.59E-03	6.46E-03	5.20E-03	3.40E-03	2.58E-03	1.36E-03	9.34E-04
0	0	0	0	0	0	0	0	0	0
2.33E-06	2.43E-06	2.26E-06	2.78E-06	2.72E-06	2.19E-06	1.43E-06	1.09E-06	5.75E-07	3.94E-07
0	0	0	0	0	0	0	0	0	0
1.11E-02	1.15E-02	1.07E-02	1.32E-02	1.29E-02	1.04E-02	6.81E-03	5.17E-03	2.73E-03	1.87E-03
2.41E-08	2.51E-08	2.34E-08	2.87E-08	2.81E-08	2.27E-08	1.48E-08	1.13E-08	5.94E-09	4.07E-09
0	0	0	0	0	0	0	0	0	0
2.11E-06	2.20E-06	2.05E-06	2.52E-06	2.47E-06	1.99E-06	1.30E-06	9.87E-07	5.21E-07	3.57E-07
1.11E-06	1.15E-06	1.07E-06	1.32E-06	1.29E-06	1.04E-06	6.81E-07	5.17E-07	2.73E-07	1.87E-07
0	0	0	0	0	0	0	0	0	0
2.62E-07	2.73E-07	2.54E-07	3.12E-07	3.06E-07	2.46E-07	1.61E-07	1.22E-07	6.46E-08	4.42E-08
3.82E-07	3.98E-07	3.71E-07	4.56E-07	4.47E-07	3.60E-07	2.35E-07	1.79E-07	9.44E-08	6.46E-08
5.02E-07	5.23E-07	4.88E-07	5.99E-07	5.87E-07	4.73E-07	3.09E-07	2.35E-07	1.24E-07	8.49E-08
0	0	0	0	0	0	0	0	0	0
8.54E-07	8.90E-07	8.29E-07	1.02E-06	9.98E-07	8.04E-07	5.25E-07	3.99E-07	2.11E-07	1.44E-07
8.44E-08	8.80E-08	8.20E-08	1.01E-07	9.87E-08	7.95E-08	5.20E-08	3.95E-08	2.08E-08	1.43E-08
1.40E-06	1.46E-06	1.36E-06	1.68E-06	1.64E-06	1.32E-06	8.64E-07	6.56E-07	3.47E-07	2.37E-07
1.11E-06	1.15E-06	1.07E-06	1.32E-06	1.29E-06	1.04E-06	6.81E-07	5.17E-07	2.73E-07	1.87E-07
1.21E-08	1.26E-08	1.17E-08	1.44E-08	1.41E-08	1.14E-08	7.44E-09	5.65E-09	2.99E-09	2.04E-09
1.90E-05	1.90E-05	1.90E-05	1.90E-05	1.90E-05	1.56E-05	1.22E-05	7.78E-06	6.65E-06	5.73E-06
4.54E-06	4.73E-06	4.41E-06	5.42E-06	5.31E-06	4.27E-06	2.79E-06	2.12E-06	1.12E-06	7.68E-07
2.01E-07	2.09E-07	1.95E-07	2.40E-07	2.35E-07	1.89E-07	1.24E-07	9.39E-08	4.96E-08	3.40E-08
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1.59E-07	1.65E-07	1.55E-07	1.84E-07	1.81E-07	1.46E-07	9.88E-08	7.28E-08	4.22E-08	3.04E-08
1.32E-06	1.35E-06	1.30E-06	1.45E-06	1.43E-06	1.16E-06	8.27E-07	5.79E-07	3.88E-07	3.04E-07
1.88E-02	1.94E-02	1.83E-02	2.17E-02	2.13E-02	1.72E-02	1.16E-02	8.55E-03	5.01E-03	3.66E-03
1.97E-01	2.02E-01	1.94E-01	2.18E-01	2.15E-01	1.75E-01	1.24E-01	8.70E-02	5.81E-02	4.54E-02
1.78E-02	1.82E-02	1.75E-02	1.97E-02	1.95E-02	1.58E-02	1.12E-02	7.87E-03	5.19E-03	4.04E-03
8.24E-05	8.45E-05	8.10E-05	9.19E-05	9.07E-05	7.36E-05	5.16E-05	3.66E-05	2.37E-05	1.83E-05
9.25E-04	9.51E-04	9.07E-04	1.04E-03	1.03E-03	8.32E-04	5.78E-04	4.14E-04	2.61E-04	1.98E-04
4.02E-01	4.06E-01	3.99E-01	4.19E-01	4.17E-01	3.41E-01	2.56E-01	1.70E-01	1.31E-01	1.09E-01
2.63E-02	2.69E-02	2.59E-02	2.91E-02	2.87E-02	2.33E-02	1.65E-02	1.16E-02	7.74E-03	6.05E-03
3.07E-01	3.10E-01	3.05E-01	3.22E-01	3.20E-01	2.61E-01	1.95E-01	1.30E-01	9.95E-02	8.24E-02
5.45E-01	5.51E-01	5.41E-01	5.73E-01	5.69E-01	4.65E-01	3.47E-01	2.31E-01	1.76E-01	1.45E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-63: Hourly GWP Emissions from NGCC (AC) in August.

Option [kg]	CO2 eq.	CO2	CH4	N2O	HFC-23	HFC-32	HFC-43-	HFC-125	HFC-134	HFC-134a	HFC-152a	HFC-143	HFC-143a	HFC-227	HFC-236	HFC-245	SF6	Perfluoromet	Perfluoroeth	Perfluorocyc	Perfluorohex	Perfluoropro	Perfluorobut	Perfluoropen
Hour 3	4.78E+01	4.35E+01	1.90E-01	9.05E-04	0	0	0	0	0	0	0	0	0	0	0	0	0	2.93E-09	3.69E-10	0	0	0	0	0
Hour 4	4.67E+01	4.26E+01	1.85E-01	8.73E-04	0	0	0	0	0	0	0	0	0	0	0	0	0	2.91E-09	3.66E-10	0	0	0	0	0
Hour 5	4.57E+01	4.17E+01	1.81E-01	8.34E-04	0	0	0	0	0	0	0	0	0	0	0	0	0	2.93E-09	3.68E-10	0	0	0	0	0
Hour 6	4.37E+01	3.98E+01	1.73E-01	7.95E-04	0	0	0	0	0	0	0	0	0	0	0	0	0	2.80E-09	3.52E-10	0	0	0	0	0
Hour 7	5.48E+01	4.99E+01	2.17E-01	1.00E-03	0	0	0	0	0	0	0	0	0	0	0	0	0	3.52E-09	4.42E-10	0	0	0	0	0
Hour 8	1.44E+02	1.32E+02	5.67E-01	2.54E-03	0	0	0	0	0	0	0	0	0	0	0	0	0	9.52E-09	1.20E-09	0	0	0	0	0
Hour 9	1.93E+02	1.76E+02	7.65E-01	3.55E-03	0	0	0	0	0	0	0	0	0	0	0	0	0	1.24E-08	1.56E-09	0	0	0	0	0
Hour 10	2.18E+02	1.99E+02	8.55E-01	3.73E-03	0	0	0	0	0	0	0	0	0	0	0	0	0	1.52E-08	1.91E-09	0	0	0	0	0
Hour 11	2.12E+02	1.94E+02	8.34E-01	3.69E-03	0	0	0	0	0	0	0	0	0	0	0	0	0	1.45E-08	1.82E-09	0	0	0	0	0
Hour 12	2.35E+02	2.15E+02	9.15E-01	3.85E-03	0	0	0	0	0	0	0	0	0	0	0	0	0	1.69E-08	2.13E-09	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
2.59E-09	2.67E-09	2.52E-09	2.98E-09	2.93E-09	2.37E-09	1.61E-09	1.18E-09	6.91E-10	5.03E-10
2.06E-08	2.13E-08	2.01E-08	2.37E-08	2.33E-08	1.89E-08	1.28E-08	9.38E-09	5.50E-09	4.00E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4.10E-03	4.14E-03	4.06E-03	4.31E-03	4.28E-03	3.50E-03	2.60E-03	1.74E-03	1.32E-03	1.09E-03
1.03E+00	1.06E+00	1.02E+00	1.14E+00	1.13E+00	9.16E-01	6.50E-01	4.55E-01	3.05E-01	2.39E-01
2.45E+02	2.51E+02	2.41E+02	2.72E+02	2.69E+02	2.18E+02	1.54E+02	1.09E+02	7.13E+01	5.53E+01
2.68E+02	2.75E+02	2.64E+02	2.98E+02	2.94E+02	2.39E+02	1.68E+02	1.19E+02	7.81E+01	6.07E+01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-64: Hourly Primary Energy Consumption from NGCC (AC) in August.

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	251.7899	251.4591	1.54E-01	1.77E-01
Hour 4	245.8438	245.5159	1.52E-01	1.76E-01
Hour 5	239.9091	239.5801	1.51E-01	1.78E-01
Hour 6	229.1788	228.8644	1.44E-01	1.70E-01
Hour 7	287.6042	287.2092	1.81E-01	2.14E-01
Hour 8	753.338	752.2713	4.85E-01	5.82E-01
Hour 9	1.02E+03	1.01E+03	6.40E-01	7.57E-01
Hour 10	1.14E+03	1.13E+03	7.59E-01	9.33E-01
Hour 11	1.11E+03	1.11E+03	7.30E-01	8.91E-01
Hour 12	1.22E+03	1.21E+03	8.36E-01	1.05E+00
Hour 13	1.38E+03	1.37E+03	9.95E-01	1.29E+00
Hour 14	1.41E+03	1.40E+03	1.03E+00	1.33E+00
Hour 15	1.35E+03	1.35E+03	9.74E-01	1.25E+00
Hour 16	1.52E+03	1.52E+03	1.13E+00	1.49E+00
Hour 17	1.50E+03	1.50E+03	1.12E+00	1.46E+00
Hour 18	1.22E+03	1.22E+03	9.04E-01	1.18E+00
Hour 19	864.4674	863.0506	6.20E-01	7.97E-01
Hour 20	605.8361	604.7987	4.49E-01	5.88E-01
Hour 21	405.2782	404.6648	2.74E-01	3.40E-01
Hour 22	317.4492	317.0007	2.04E-01	2.45E-01

Table H-65: Hourly Air Emissions from Average Electric Mix (EC) in August.

Zinc	2.97E-07	2.97E-07	2.97E-07	2.97E-07	2.97E-07	1.04E-06	9.41E-07	9.41E-07	9.41E-07	1.04E-06
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	5.64E-05	5.64E-05	5.64E-05	5.64E-05	5.64E-05	1.97E-04	1.79E-04	1.79E-04	1.79E-04	1.97E-04
VOC	0	0	0	0	0	0	0	0	0	0
Vanadiu	2.38E-08	2.38E-08	2.38E-08	2.38E-08	2.38E-08	8.32E-08	7.53E-08	7.53E-08	7.53E-08	8.32E-08
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	3.96E-04	3.58E-04	3.58E-04	3.58E-04	3.96E-04
Selenium	2.46E-10	2.46E-10	2.46E-10	2.46E-10	2.46E-10	8.61E-10	7.79E-10	7.79E-10	7.79E-10	8.61E-10
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	2.16E-08	2.16E-08	2.16E-08	2.16E-08	2.16E-08	7.54E-08	6.83E-08	6.83E-08	6.83E-08	7.54E-08
Molybde	1.13E-08	1.13E-08	1.13E-08	1.13E-08	1.13E-08	3.96E-08	3.58E-08	3.58E-08	3.58E-08	3.96E-08
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	2.67E-09	2.67E-09	2.67E-09	2.67E-09	2.67E-09	9.35E-09	8.46E-09	8.46E-09	8.46E-09	9.35E-09
Mangane	3.90E-09	3.90E-09	3.90E-09	3.90E-09	3.90E-09	1.37E-08	1.24E-08	1.24E-08	1.24E-08	1.37E-08
Lead	5.13E-09	5.13E-09	5.13E-09	5.13E-09	5.13E-09	1.79E-08	1.62E-08	1.62E-08	1.62E-08	1.79E-08
HC	0	0	0	0	0	0	0	0	0	0
Copper	8.72E-09	8.72E-09	8.72E-09	8.72E-09	8.72E-09	3.05E-08	2.76E-08	2.76E-08	2.76E-08	3.05E-08
Cobalt	8.62E-10	8.62E-10	8.62E-10	8.62E-10	8.62E-10	3.02E-09	2.73E-09	2.73E-09	2.73E-09	3.02E-09
Chromiu	1.43E-08	1.43E-08	1.43E-08	1.43E-08	1.43E-08	5.02E-08	4.54E-08	4.54E-08	4.54E-08	5.02E-08
Cadmiu	1.13E-08	1.13E-08	1.13E-08	1.13E-08	1.13E-08	3.96E-08	3.58E-08	3.58E-08	3.58E-08	3.96E-08
Beryllju	1.23E-10	1.23E-10	1.23E-10	1.23E-10	1.23E-10	4.32E-10	3.91E-10	3.91E-10	3.91E-10	4.32E-10
Benzene	0	0	0	0	0	0	0	0	0	0
Barium	4.64E-08	4.64E-08	4.64E-08	4.64E-08	4.64E-08	1.62E-07	1.47E-07	1.47E-07	1.47E-07	1.62E-07
arsenic	2.05E-09	2.05E-09	2.05E-09	2.05E-09	2.05E-09	7.18E-09	6.50E-09	6.50E-09	6.50E-09	7.18E-09
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetalde	0	0	0	0	0	0	0	0	0	0
NH3	2.05E-06	1.98E-06	1.89E-06	1.81E-06	2.28E-06	5.80E-06	8.09E-06	8.60E-06	8.47E-06	8.92E-06
H2S	1.21E-08	1.20E-08	1.18E-08	1.15E-08	1.27E-08	3.91E-08	4.23E-08	4.35E-08	4.32E-08	4.67E-08
NMVOC	2.08E-02	2.01E-02	1.92E-02	1.83E-02	2.32E-02	5.89E-02	8.20E-02	8.71E-02	8.59E-02	9.04E-02
CO	5.36E-02	5.19E-02	4.97E-02	4.75E-02	5.98E-02	1.53E-01	2.11E-01	2.24E-01	2.21E-01	2.33E-01
Particulat	8.01E-03	7.74E-03	7.42E-03	7.08E-03	8.93E-03	2.27E-02	3.16E-02	3.35E-02	3.31E-02	3.48E-02
HF	2.40E-04	2.32E-04	2.22E-04	2.12E-04	2.68E-04	6.80E-04	9.48E-04	1.01E-03	9.93E-04	1.05E-03
HCl	4.82E-03	4.66E-03	4.46E-03	4.25E-03	5.38E-03	1.37E-02	1.90E-02	2.02E-02	2.00E-02	2.10E-02
NOx	2.13E-01	2.06E-01	1.98E-01	1.88E-01	2.38E-01	6.05E-01	8.43E-01	8.96E-01	8.83E-01	9.30E-01
SO2	6.48E-02	6.27E-02	6.00E-02	5.72E-02	7.24E-02	1.84E-01	2.56E-01	2.72E-01	2.68E-01	2.83E-01
SO2 eq.	2.18E-01	2.11E-01	2.02E-01	1.93E-01	2.43E-01	6.18E-01	8.61E-01	9.15E-01	9.02E-01	9.50E-01
TOPP eq.	2.89E-01	2.80E-01	2.68E-01	2.55E-01	3.23E-01	8.20E-01	1.14E+0	1.21E+0	1.20E+0	1.26E+0
Option	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

9.41E-07	9.41E-07	9.41E-07	1.04E-06	1.04E-06	8.42E-07	5.94E-07	3.96E-07	2.97E-07	2.97E-07
0	0	0	0	0	0	0	0	0	0
1.79E-04	1.79E-04	1.79E-04	1.97E-04	1.97E-04	1.60E-04	1.13E-04	7.52E-05	5.64E-05	5.64E-05
0	0	0	0	0	0	0	0	0	0
7.53E-08	7.53E-08	7.53E-08	8.32E-08	8.32E-08	6.74E-08	4.75E-08	3.17E-08	2.38E-08	2.38E-08
0	0	0	0	0	0	0	0	0	0
3.58E-04	3.58E-04	3.58E-04	3.96E-04	3.96E-04	3.20E-04	2.26E-04	1.51E-04	1.13E-04	1.13E-04
7.79E-10	7.79E-10	7.79E-10	8.61E-10	8.61E-10	6.97E-10	4.92E-10	3.28E-10	2.46E-10	2.46E-10
0	0	0	0	0	0	0	0	0	0
6.83E-08	6.83E-08	6.83E-08	7.54E-08	7.54E-08	6.11E-08	4.31E-08	2.87E-08	2.16E-08	2.16E-08
3.58E-08	3.58E-08	3.58E-08	3.96E-08	3.96E-08	3.20E-08	2.26E-08	1.51E-08	1.13E-08	1.13E-08
0	0	0	0	0	0	0	0	0	0
8.46E-09	8.46E-09	8.46E-09	9.35E-09	9.35E-09	7.57E-09	5.34E-09	3.56E-09	2.67E-09	2.67E-09
1.24E-08	1.24E-08	1.24E-08	1.37E-08	1.37E-08	1.11E-08	7.81E-09	5.20E-09	3.90E-09	3.90E-09
1.62E-08	1.62E-08	1.62E-08	1.79E-08	1.79E-08	1.45E-08	1.03E-08	6.84E-09	5.13E-09	5.13E-09
0	0	0	0	0	0	0	0	0	0
2.76E-08	2.76E-08	2.76E-08	3.05E-08	3.05E-08	2.47E-08	1.74E-08	1.16E-08	8.72E-09	8.72E-09
2.73E-09	2.73E-09	2.73E-09	3.02E-09	3.02E-09	2.44E-09	1.72E-09	1.15E-09	8.62E-10	8.62E-10
4.54E-08	4.54E-08	4.54E-08	5.02E-08	5.02E-08	4.06E-08	2.87E-08	1.91E-08	1.43E-08	1.43E-08
3.58E-08	3.58E-08	3.58E-08	3.96E-08	3.96E-08	3.20E-08	2.26E-08	1.51E-08	1.13E-08	1.13E-08
3.91E-10	3.91E-10	3.91E-10	4.32E-10	4.32E-10	3.50E-10	2.47E-10	1.65E-10	1.23E-10	1.23E-10
0	0	0	0	0	0	0	0	0	0
1.47E-07	1.47E-07	1.47E-07	1.62E-07	1.62E-07	1.31E-07	9.27E-08	6.18E-08	4.64E-08	4.64E-08
6.50E-09	6.50E-09	6.50E-09	7.18E-09	7.18E-09	5.81E-09	4.10E-09	2.74E-09	2.05E-09	2.05E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
9.61E-06	9.74E-06	9.52E-06	1.02E-05	1.01E-05	8.26E-06	6.10E-06	4.11E-06	3.04E-06	2.48E-06
4.60E-08	4.63E-08	4.58E-08	4.98E-08	4.96E-08	4.03E-08	2.91E-08	1.95E-08	1.45E-08	1.32E-08
9.73E-02	9.86E-02	9.64E-02	1.03E-01	1.03E-01	8.37E-02	6.17E-02	4.16E-02	3.08E-02	2.52E-02
2.51E-01	2.54E-01	2.48E-01	2.66E-01	2.64E-01	2.15E-01	1.59E-01	1.07E-01	7.93E-02	6.49E-02
3.75E-02	3.80E-02	3.71E-02	3.98E-02	3.95E-02	3.22E-02	2.38E-02	1.60E-02	1.19E-02	9.69E-03
1.13E-03	1.14E-03	1.12E-03	1.19E-03	1.19E-03	9.68E-04	7.14E-04	4.82E-04	3.57E-04	2.91E-04
2.26E-02	2.29E-02	2.24E-02	2.40E-02	2.38E-02	1.95E-02	1.44E-02	9.68E-03	7.17E-03	5.85E-03
1.00E+0	1.01E+0	9.92E-01	1.06E+0	1.05E+0	8.61E-01	6.35E-01	4.28E-01	3.17E-01	2.59E-01
3.04E-01	3.08E-01	3.01E-01	3.23E-01	3.21E-01	2.62E-01	1.93E-01	1.30E-01	9.64E-02	7.86E-02
1.02E+0	1.04E+0	1.01E+0	1.09E+0	1.08E+0	8.80E-01	6.49E-01	4.38E-01	3.24E-01	2.64E-01
1.36E+0	1.38E+0	1.34E+0	1.44E+0	1.43E+0	1.17E+0	8.61E-01	5.80E-01	4.30E-01	3.51E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-66: Hourly GWP Emissions from Average Electric Mix (EC) in August.

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Perfluoropen	0	0	0	0	0	0	0	0	0	0
Perfluorobut	0	0	0	0	0	0	0	0	0	0
Perfluoropro	0	0	0	0	0	0	0	0	0	0
Perfluorohex	0	0	0	0	0	0	0	0	0	0
Perfluorocyc	0	0	0	0	0	0	0	0	0	0
Perfluoroeth	2.96E-08	2.86E-08	2.74E-08	2.61E-08	3.31E-08	8.39E-08	1.17E-07	1.24E-07	1.23E-07	1.29E-07
Perfluoromet	2.36E-07	2.28E-07	2.18E-07	2.08E-07	2.63E-07	6.67E-07	9.31E-07	9.89E-07	9.76E-07	1.03E-06
SF6	0	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0	0
HFC-43-	0	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0	0
HFC-23	0	0	0	0	0	0	0	0	0	0
N2O	3.37E-03	3.25E-03	3.12E-03	2.97E-03	3.76E-03	9.54E-03	1.33E-02	1.41E-02	1.39E-02	1.47E-02
CH4	1.57E-01	1.52E-01	1.46E-01	1.40E-01	1.75E-01	4.49E-01	6.18E-01	6.55E-01	6.46E-01	6.81E-01
CO2	6.27E+0	6.07E+0	5.82E+0	5.55E+0	6.98E+0	1.79E+0	2.47E+0	2.62E+0	2.58E+0	2.72E+0
CO2 eq.	6.71E+0	6.49E+0	6.22E+0	5.94E+0	7.47E+0	1.91E+0	2.64E+0	2.80E+0	2.76E+0	2.91E+0

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1.39E-07	1.41E-07	1.38E-07	1.48E-07	1.46E-07	1.20E-07	8.82E-08	5.95E-08	4.40E-08	3.59E-08
1.11E-06	1.12E-06	1.10E-06	1.17E-06	1.17E-06	9.51E-07	7.02E-07	4.73E-07	3.50E-07	2.86E-07
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1.58E-02	1.60E-02	1.56E-02	1.68E-02	1.66E-02	1.36E-02	1.00E-02	6.75E-03	5.00E-03	4.08E-03
7.31E-01	7.40E-01	7.24E-01	7.76E-01	7.70E-01	6.29E-01	4.63E-01	3.12E-01	2.31E-01	1.90E-01
2.92E+02	2.96E+02	2.90E+02	3.10E+02	3.08E+02	2.51E+02	1.85E+02	1.25E+02	9.26E+01	7.58E+01
3.13E+02	3.17E+02	3.10E+02	3.32E+02	3.30E+02	2.69E+02	1.98E+02	1.34E+02	9.90E+01	8.10E+01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-67: Hourly Primary Energy Consumption from Average Electric (EC) in August.

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.65E+02	2.40E+02	8.17E+00	1.65E+01
Hour 4	2.56E+02	2.32E+02	7.90E+00	1.60E+01
Hour 5	2.46E+02	2.23E+02	7.57E+00	1.53E+01
Hour 6	2.35E+02	2.13E+02	7.21E+00	1.46E+01
Hour 7	2.95E+02	2.67E+02	9.12E+00	1.84E+01
Hour 8	7.55E+02	6.85E+02	2.31E+01	4.68E+01
Hour 9	1.04E+03	9.43E+02	3.23E+01	6.53E+01
Hour 10	1.10E+03	1.00E+03	3.43E+01	6.94E+01
Hour 11	1.09E+03	9.87E+02	3.38E+01	6.84E+01
Hour 12	1.15E+03	1.04E+03	3.56E+01	7.20E+01
Hour 13	1.23E+03	1.12E+03	3.84E+01	7.76E+01
Hour 14	1.25E+03	1.13E+03	3.89E+01	7.86E+01
Hour 15	1.22E+03	1.11E+03	3.80E+01	7.68E+01
Hour 16	1.31E+03	1.19E+03	4.07E+01	8.23E+01
Hour 17	1.30E+03	1.18E+03	4.04E+01	8.17E+01
Hour 18	1.06E+03	9.60E+02	3.30E+01	6.67E+01
Hour 19	7.82E+02	7.08E+02	2.43E+01	4.92E+01
Hour 20	5.27E+02	4.77E+02	1.64E+01	3.32E+01
Hour 21	3.90E+02	3.54E+02	1.22E+01	2.46E+01
Hour 22	3.20E+02	2.90E+02	9.91E+00	2.00E+01

Table H-68: Hourly Air Emissions from Average Electric Mix (AC) in August.

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Zinc	3.36E-06	3.41E-06	3.55E-06	3.41E-06	4.21E-06	1.21E-05	1.48E-05	1.96E-05	1.84E-05	2.27E-05
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	6.38E-04	6.47E-04	6.74E-04	6.47E-04	8.00E-04	2.29E-03	2.81E-03	3.72E-03	3.50E-03	4.32E-03
VOC	0	0	0	0	0	0	0	0	0	0
Vanadium	2.69E-07	2.73E-07	2.84E-07	2.73E-07	3.37E-07	9.66E-07	1.18E-06	1.57E-06	1.48E-06	1.82E-06
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	1.28E-03	1.30E-03	1.35E-03	1.30E-03	1.60E-03	4.59E-03	5.63E-03	7.44E-03	7.01E-03	8.65E-03
Selenium	2.78E-09	2.82E-09	2.94E-09	2.82E-09	3.49E-09	9.99E-09	1.23E-08	1.62E-08	1.53E-08	1.88E-08
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	2.44E-07	2.47E-07	2.58E-07	2.47E-07	3.06E-07	8.76E-07	1.07E-06	1.42E-06	1.34E-06	1.65E-06
Molybdenu	1.28E-07	1.30E-07	1.35E-07	1.30E-07	1.60E-07	4.59E-07	5.63E-07	7.44E-07	7.01E-07	8.65E-07
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	3.02E-08	3.07E-08	3.19E-08	3.07E-08	3.79E-08	1.09E-07	1.33E-07	1.76E-07	1.66E-07	2.04E-07
Manganese	4.42E-08	4.48E-08	4.66E-08	4.48E-08	5.53E-08	1.59E-07	1.94E-07	2.57E-07	2.42E-07	2.99E-07
Lead	5.80E-08	5.88E-08	6.13E-08	5.88E-08	7.27E-08	2.08E-07	2.56E-07	3.38E-07	3.18E-07	3.92E-07
HC	0	0	0	0	0	0	0	0	0	0
Copper	9.87E-08	1.00E-07	1.04E-07	1.00E-07	1.24E-07	3.54E-07	4.34E-07	5.74E-07	5.41E-07	6.67E-07
Cobalt	9.76E-09	9.90E-09	1.03E-08	9.90E-09	1.22E-08	3.50E-08	4.30E-08	5.68E-08	5.35E-08	6.60E-08
Chromium	1.62E-07	1.65E-07	1.71E-07	1.65E-07	2.03E-07	5.83E-07	7.14E-07	9.44E-07	8.90E-07	1.10E-06
Cadmium	1.28E-07	1.30E-07	1.35E-07	1.30E-07	1.60E-07	4.59E-07	5.63E-07	7.44E-07	7.01E-07	8.65E-07
Beryllium	1.40E-09	1.42E-09	1.48E-09	1.42E-09	1.75E-09	5.02E-09	6.15E-09	8.13E-09	7.66E-09	9.45E-09
Benzene	0	0	0	0	0	0	0	0	0	0
Barium	5.25E-07	5.32E-07	5.54E-07	5.32E-07	6.57E-07	1.88E-06	2.31E-06	3.05E-06	2.88E-06	3.55E-06
arsenic	2.32E-08	2.35E-08	2.45E-08	2.35E-08	2.91E-08	8.34E-08	1.02E-07	1.35E-07	1.27E-07	1.57E-07
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehyd	0	0	0	0	0	0	0	0	0	0
NH3	1.73E-06	1.66E-06	1.56E-06	1.48E-06	1.88E-06	4.65E-06	6.65E-06	6.67E-06	6.66E-06	6.69E-06
H2S	8.50E-08	8.59E-08	8.91E-08	8.55E-08	1.06E-07	3.01E-07	3.72E-07	4.86E-07	4.59E-07	5.62E-07
NMVOC	1.91E-02	1.83E-02	1.74E-02	1.66E-02	2.10E-02	5.28E-02	7.42E-02	7.67E-02	7.61E-02	7.83E-02
CO	5.64E-02	5.46E-02	5.26E-02	5.02E-02	6.32E-02	1.62E-01	2.23E-01	2.41E-01	2.37E-01	2.52E-01
Particulates	7.80E-03	7.53E-03	7.20E-03	6.86E-03	8.66E-03	2.20E-02	3.06E-02	3.23E-02	3.19E-02	3.33E-02
HF	2.07E-04	1.98E-04	1.87E-04	1.78E-04	2.26E-04	5.61E-04	7.98E-04	8.06E-04	8.04E-04	8.12E-04
HCl	4.12E-03	3.94E-03	3.71E-03	3.54E-03	4.48E-03	1.11E-02	1.59E-02	1.60E-02	1.59E-02	1.60E-02
NOx	1.89E-01	1.81E-01	1.72E-01	1.63E-01	2.07E-01	5.16E-01	7.31E-01	7.46E-01	7.42E-01	7.55E-01
SO2	5.60E-02	5.37E-02	5.06E-02	4.82E-02	6.11E-02	1.52E-01	2.16E-01	2.18E-01	2.18E-01	2.20E-01
SO2 eq.	1.91E-01	1.84E-01	1.74E-01	1.65E-01	2.09E-01	5.22E-01	7.41E-01	7.53E-01	7.50E-01	7.61E-01
TOPP eq.	2.58E-01	2.48E-01	2.35E-01	2.24E-01	2.83E-01	7.08E-01	1.00E+0	1.03E+0	1.02E+0	1.04E+0

2.91E-05	3.03E-05	2.83E-05	3.47E-05	3.40E-05	2.74E-05	1.79E-05	1.36E-05	7.18E-06	4.92E-06
0	0	0	0	0	0	0	0	0	0
5.52E-03	5.76E-03	5.36E-03	6.59E-03	6.46E-03	5.20E-03	3.40E-03	2.58E-03	1.36E-03	9.34E-04
0	0	0	0	0	0	0	0	0	0
2.33E-06	2.43E-06	2.26E-06	2.78E-06	2.72E-06	2.19E-06	1.43E-06	1.09E-06	5.75E-07	3.94E-07
0	0	0	0	0	0	0	0	0	0
1.11E-02	1.15E-02	1.07E-02	1.32E-02	1.29E-02	1.04E-02	6.81E-03	5.17E-03	2.73E-03	1.87E-03
2.41E-08	2.51E-08	2.34E-08	2.87E-08	2.81E-08	2.27E-08	1.48E-08	1.13E-08	5.94E-09	4.07E-09
0	0	0	0	0	0	0	0	0	0
2.11E-06	2.20E-06	2.05E-06	2.52E-06	2.47E-06	1.99E-06	1.30E-06	9.87E-07	5.21E-07	3.57E-07
1.11E-06	1.15E-06	1.07E-06	1.32E-06	1.29E-06	1.04E-06	6.81E-07	5.17E-07	2.73E-07	1.87E-07
0	0	0	0	0	0	0	0	0	0
2.62E-07	2.73E-07	2.54E-07	3.12E-07	3.06E-07	2.46E-07	1.61E-07	1.22E-07	6.46E-08	4.42E-08
3.82E-07	3.98E-07	3.71E-07	4.56E-07	4.47E-07	3.60E-07	2.35E-07	1.79E-07	9.44E-08	6.46E-08
5.02E-07	5.23E-07	4.88E-07	5.99E-07	5.87E-07	4.73E-07	3.09E-07	2.35E-07	1.24E-07	8.49E-08
0	0	0	0	0	0	0	0	0	0
8.54E-07	8.90E-07	8.29E-07	1.02E-06	9.98E-07	8.04E-07	5.25E-07	3.99E-07	2.11E-07	1.44E-07
8.44E-08	8.80E-08	8.20E-08	1.01E-07	9.87E-08	7.95E-08	5.20E-08	3.95E-08	2.08E-08	1.43E-08
1.40E-06	1.46E-06	1.36E-06	1.68E-06	1.64E-06	1.32E-06	8.64E-07	6.56E-07	3.47E-07	2.37E-07
1.11E-06	1.15E-06	1.07E-06	1.32E-06	1.29E-06	1.04E-06	6.81E-07	5.17E-07	2.73E-07	1.87E-07
1.21E-08	1.26E-08	1.17E-08	1.44E-08	1.41E-08	1.14E-08	7.44E-09	5.65E-09	2.99E-09	2.04E-09
0	0	0	0	0	0	0	0	0	0
4.54E-06	4.73E-06	4.41E-06	5.42E-06	5.31E-06	4.27E-06	2.79E-06	2.12E-06	1.12E-06	7.68E-07
2.01E-07	2.09E-07	1.95E-07	2.40E-07	2.35E-07	1.89E-07	1.24E-07	9.39E-08	4.96E-08	3.40E-08
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
6.72E-06	6.72E-06	6.71E-06	6.73E-06	6.74E-06	5.53E-06	4.32E-06	2.75E-06	2.33E-06	2.00E-06
7.15E-07	7.44E-07	6.95E-07	8.50E-07	8.33E-07	6.71E-07	4.40E-07	3.33E-07	1.78E-07	1.23E-07
8.16E-02	8.23E-02	8.12E-02	8.45E-02	8.42E-02	6.89E-02	5.21E-02	3.43E-02	2.70E-02	2.26E-02
2.76E-01	2.80E-01	2.73E-01	2.96E-01	2.94E-01	2.39E-01	1.74E-01	1.19E-01	8.54E-02	6.90E-02
3.55E-02	3.60E-02	3.53E-02	3.75E-02	3.72E-02	3.04E-02	2.26E-02	1.51E-02	1.14E-02	9.38E-03
8.22E-04	8.24E-04	8.21E-04	8.32E-04	8.31E-04	6.82E-04	5.28E-04	3.39E-04	2.82E-04	2.41E-04
1.62E-02	1.62E-02	1.61E-02	1.63E-02	1.63E-02	1.33E-02	1.04E-02	6.64E-03	5.58E-03	4.78E-03
7.75E-01	7.79E-01	7.72E-01	7.92E-01	7.90E-01	6.47E-01	4.96E-01	3.22E-01	2.62E-01	2.22E-01
2.23E-01	2.24E-01	2.23E-01	2.26E-01	2.26E-01	1.85E-01	1.43E-01	9.21E-02	7.65E-02	6.53E-02
7.78E-01	7.81E-01	7.76E-01	7.93E-01	7.91E-01	6.48E-01	4.98E-01	3.23E-01	2.64E-01	2.24E-01
1.07E+0	1.08E+0	1.07E+0	1.10E+0	1.10E+0	8.98E-01	6.85E-01	4.47E-01	3.60E-01	3.04E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-69: Hourly GWP Emissions from Average Electric Mix (AC) in August.

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
Perfluoropentan	0	0	0	0	0	0	0	0	0
Perfluorobutane	0	0	0	0	0	0	0	0	0
Perfluoropropane	0	0	0	0	0	0	0	0	0
Perfluorohexane	0	0	0	0	0	0	0	0	0
Perfluorocyclobutane	0	0	0	0	0	0	0	0	0
Perfluoroethane	2.51E-08	2.40E-08	2.26E-08	2.15E-08	2.73E-08	6.75E-08	9.65E-08	9.68E-08	9.67E-08
Perfluoromethane	1.99E-07	1.91E-07	1.80E-07	1.71E-07	2.17E-07	5.37E-07	7.68E-07	7.70E-07	7.70E-07
SF6	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0
HFC-43-10mee	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0
HFC-23	0	0	0	0	0	0	0	0	0
N2O	2.95E-03	2.83E-03	2.67E-03	2.54E-03	3.22E-03	8.03E-03	1.14E-02	1.16E-02	1.15E-02
CH4	1.91E-01	1.86E-01	1.82E-01	1.74E-01	2.18E-01	5.70E-01	7.69E-01	8.59E-01	8.38E-01
CO2	6.77E+01	6.57E+01	6.35E+01	6.06E+01	7.62E+01	1.97E+02	2.69E+02	2.92E+02	2.87E+02
CO2 eq.	7.27E+01	7.05E+01	6.81E+01	6.50E+01	8.18E+01	2.11E+02	2.89E+02	3.14E+02	3.08E+02

0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
9.70E-08	9.75E-08	9.75E-08	9.74E-08	9.78E-08	9.78E-08	8.03E-08	6.26E-08	4.00E-08	3.39E-08	2.91E-08
7.72E-07	7.75E-07	7.76E-07	7.75E-07	7.79E-07	7.78E-07	6.39E-07	4.98E-07	3.18E-07	2.69E-07	2.31E-07
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
1.17E-02	1.19E-02	1.20E-02	1.19E-02	1.22E-02	1.21E-02	9.94E-03	7.65E-03	4.95E-03	4.06E-03	3.45E-03
9.19E-01	1.04E+0	1.06E+0	1.02E+0	1.15E+0	1.13E+0	9.20E-01	6.53E-01	4.57E-01	3.07E-01	2.40E-01
3.08E+0	3.38E+0	3.44E+0	3.34E+0	3.66E+0	3.62E+0	2.95E+0	2.14E+0	1.47E+0	1.04E+0	8.33E+0
330.5939	363.9274	370.3497	359.4811	393.3355	389.6301	3.17E+0	2.30E+0	1.58E+0	1.12E+0	8.95E+0
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-70: Hourly Primary Energy Consumption from Average Electric (AC) in August.

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	301	280	6.94E+00	1.40E+01
Hour 4	293	273	6.65E+00	1.34E+01
Hour 5	284	265	6.26E+00	1.26E+01
Hour 6	271	253	5.97E+00	1.20E+01
Hour 7	341	318	7.55E+00	1.52E+01
Hour 8	886	829	1.87E+01	3.77E+01
Hour 9	1.21E+03	1.12E+03	2.67E+01	5.38E+01
Hour 10	1.33E+03	1.25E+03	2.69E+01	5.40E+01
Hour 11	1.30E+03	1.22E+03	2.68E+01	5.39E+01
Hour 12	1.41E+03	1.33E+03	2.69E+01	5.41E+01
Hour 13	1.57E+03	1.49E+03	2.71E+01	5.43E+01
Hour 14	1.60E+03	1.52E+03	2.71E+01	5.44E+01
Hour 15	1.55E+03	1.46E+03	2.71E+01	5.43E+01
Hour 16	1.71E+03	1.63E+03	2.72E+01	5.45E+01
Hour 17	1.69E+03	1.61E+03	2.72E+01	5.45E+01
Hour 18	1.38E+03	1.31E+03	2.23E+01	4.48E+01
Hour 19	987.5704718	935.2558	1.74E+01	3.49E+01
Hour 20	684.1206289	650.7236	1.11E+01	2.23E+01
Hour 21	472.1396308	443.8672	9.39E+00	1.89E+01
Hour 22	374.6441781	350.3603	8.06E+00	1.62E+01

Thermal Load Following: Daily Data

Table H-71: Air Emissions from Energy Systems in a Typical Day in January (TLF).

Option [kg]	143-kW ICE	3-MW ICE	Microturbine	Base Case	SOFC 26%	Base Case	SOFC 33%
Benzene	14	14	0	0	0	0	0
Barium	0	0	0	0	0	0	0
arsenic	0	0	0	0	0	0	0
Acrolein	0	0	0	0	0	0	0
Acetaldehyde	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0
H2S	0	0	0	0	0	0	0
NMVOC	0	0	0	0	0	1	0
CO	26	32	3	3	3	4	2
Particulates	0	0	0	0	0	1	0
HF	0	0	0	0	0	0	0
HCl	0	0	0	0	0	0	0
NOx	4	5	2	6	4	12	3
SO2	0	0	0	0	0	3	0
AP	3	4	2	5	3	12	2
TOPP	8	10	3	8	6	16	4

Table H-72: GWP Emissions from Energy Systems in a Typical Day in January (TLF).

Option [kg]	GWP	CO2	CH4	N2O
143-kW ICE	3592.01	3199.21	17.09	0.11
3-MW ICE	4442.98	3957.11	21.14	0.14
Microturbine	3982.23	3681.84	14.19	0.01
Base Case NGCC	4056.33	3707.80	15.71	0.06
SOFC 26% thermal	8078.54	7644.17	20.20	0.03
SOFC 33% thermal	6365.72	6023.31	15.92	0.02
Base Case Electric	5508.35	5121.32	15.78	0.18

Table H-73: Primary Energy Consumption from Energy Systems in a Typical Day in January (TLF).

Option [kWh]	Sum	non renewable	renewable	other
143-kW ICE	19512	19496	9	7
3-MW ICE	24133	24112	11	9
Microturbine	19023	19008	8	7
Base Case NGCC	20872	20855	9	7
SOFC 26% thermal	39291	39231	21	39
SOFC 33% thermal	30959	30911	16	31
Base Case Electric	23758	22539	405	813

Table H-74: Air Emissions from Energy Systems in a Typical Day in May (TLF).

Option [kg]	3-MW ICE	Microturbine	Base Case NGCC	SOFC 26% thermal	143-kW ICE	Base Case Electric
Benzene	7.0	0.0	0.0	0.0	7.0	0.0
Barium	0.0	0.0	0.0	0.0	0.0	0.0
arsenic	0.0	0.0	0.0	0.0	0.0	0.0
Acrolein	0.0	0.0	0.0	0.0	0.0	0.0
Acetaldehyde	0.0	0.0	0.0	0.0	0.0	0.0
NH3	0.0	0.0	0.0	0.0	0.0	0.0
H2S	0.0	0.0	0.0	0.0	0.0	0.0
NMVOC	0.2	0.4	0.2	0.2	0.5	1.1
CO	16.3	2.7	2.1	1.3	14.0	3.3
Particulates	0.2	0.2	0.2	0.1	0.3	0.4
HF	0.0	0.0	0.0	0.0	0.0	0.0
HCl	0.0	0.1	0.0	0.0	0.1	0.2
NOx	2.4	4.7	5.2	2.0	5.2	10.6
SO2	0.2	1.3	0.3	0.1	1.2	3.1
AP	1.9	4.7	3.9	1.5	4.9	10.8
TOPP	5.1	6.5	6.9	2.9	8.6	14.6

Table H-75: GWP Emissions from Energy Systems in a Typical Day in May (TLF).

Option [kg]	GWP	CO2	CH4	N2O
3-MW ICE	2256.2	2010.4	10.7	0.1
Microturbine	3165.2	2939.2	9.8	0.1
Base Case NGCC	2858.6	2605.6	11.3	0.1
SOFC	4082.6	3862.8	10.2	0.0
143-kW ICE	2827.8	2564.3	11.0	0.1
Base Case Electric	4245.2	3955.4	11.3	0.2

Table H-76: Primary Energy Consumption from Energy Systems in a Typical Day in May (TLF).

Option [kWh]	Sum	non renewable	renewable	other
3-MW ICE	12233	12214	8	11
Microturbine	14127	13681	149	297
Base Case NGCC	14980	14959	10	11
SOFC	19834	19795	13	26
143-kW ICE	13825	13432	132	261
Base Case Electric	17734	16565	388	781

Table H-77: Air Emissions from Energy Systems in a Typical Day in August (TLF).

Option [kg]	3-MW ICE	Microturbine	Base Case NGCC	SOFC	143-kW ICE	Base Case Electric
Benzene	10.9	0.0	0.0	0.0	10.9	0.0
Barium	0.0	0.0	0.0	0.0	0.0	0.0
Arsenic	0.0	0.0	0.0	0.0	0.0	0.0
Acrolein	0.0	0.0	0.0	0.0	0.0	0.0
Acetaldehyde	0.0	0.0	0.0	0.0	0.0	0.0
NH3	0.0	0.0	0.0	0.0	0.0	0.0
H2S	0.0	0.0	0.0	0.0	0.0	0.0
NMVOC	0.4	0.1	0.2	0.3	0.3	1.2
CO	25.3	2.8	2.6	2.0	20.4	3.8
Particulates	0.3	0.1	0.2	0.2	0.3	0.5
HF	0.0	0.0	0.0	0.0	0.0	0.0
HCl	0.0	0.0	0.0	0.0	0.0	0.2
NOx	3.8	1.9	5.7	3.1	3.1	11.1
SO2	0.3	0.4	0.3	0.2	0.3	3.2
AP	3.0	1.7	4.3	2.4	2.4	11.2
TOPP	8.0	2.9	7.6	4.6	6.5	15.3

Table H-78: GWP Emissions from Energy Systems in a Typical Day in August (TLF).

Option [kg]	GWP	CO2	CH4	N2O
3-MW ICE	3497.5	3116.5	16.6	0.1
Microturbine	3255.0	3011.0	11.4	0.0
Base Case NGCC	3523.9	3218.6	13.7	0.1
SOFC	6328.0	5987.3	15.8	0.0
143-kW ICE	2834.7	2526.3	13.4	0.1
Base Case Electric	4924.5	4582.2	13.8	0.2
Option [kg]	GWP	CO2	CH4	N2O
3-MW ICE	3497.5	3116.5	16.6	0.1
Microturbine	3255.0	3011.0	11.4	0.0
Base Case NGCC	3523.9	3218.6	13.7	0.1
SOFC	6328.0	5987.3	15.8	0.0
143-kW ICE	2834.7	2526.3	13.4	0.1
Base Case Electric	4924.5	4582.2	13.8	0.2

Table H-79: Primary Energy Consumption from Energy Systems in a Typical Day in August (TLF).

Option [kWh]	Sum	non renewable	renewable	other
3-MW ICE	18962	18932	13	17
Microturbine	15423	15353	26	44
Base Case NGCC	18209	18181	13	16
SOFC	30741	30680	21	40
143-kW ICE	15347	15320	11	15
Base Case Electric	20988	19801	395	793

Thermal Load Following: Hourly Data

Table H-80: Hourly Air Emissions from SOFC in January (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
TOPP eq.	0.24	0.24	0.26	0.27	0.27	0.34	0.25	0.22	0.22
SO2	0.12	0.13	0.13	0.14	0.14	0.18	0.13	0.11	0.11
SO2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NOx	0.16	0.17	0.17	0.18	0.18	0.23	0.17	0.15	0.15
HCl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Particulates	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CO	0.11	0.11	0.12	0.12	0.12	0.16	0.11	0.10	0.10
NMVOC	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
0.09	0.07	0.06	0.07	0.08	0.10	0.12	0.13	0.10	0.11	0.12
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.13	0.11	0.10	0.10	0.12	0.14	0.17	0.20	0.15	0.17	0.18
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.10	0.08	0.07	0.08	0.09	0.11	0.13	0.15	0.11	0.13	0.13
0.19	0.16	0.14	0.15	0.18	0.21	0.25	0.29	0.22	0.24	0.26
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-81: GWP Emissions from SOFC in January (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
CO_2	344.79	348.37	364.45	379.63	382.31	491.29	351.94	315.32	310.85	273.33
CO_2	326.25	329.64	344.85	359.22	361.75	464.87	333.02	298.36	294.14	258.64
CH_4	0.86	0.87	0.91	0.95	0.96	1.23	0.88	0.79	0.78	0.68
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorometh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroetha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocycl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohexa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroprop	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobuta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.59	0.51	0.53	0.65	0.76	0.91	1.03	0.80	0.87	0.92
222.29	192.71	199.47	245.11	286.53	344.00	389.65	300.90	329.64	349.92
234.92	203.66	210.81	259.04	302.81	363.55	411.79	318.00	348.37	369.80
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-82: Hourly Primary Energy Consumption from SOFC in January (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	1676.94	1674.38	0.88	1.68
Hour 4	1694.31	1691.73	0.88	1.70
Hour 5	1772.51	1769.81	0.93	1.78
Hour 6	1846.37	1843.55	0.96	1.85
Hour 7	1859.40	1856.57	0.97	1.86
Hour 8	2389.42	2385.78	1.25	2.39
Hour 9	1711.69	1709.08	0.89	1.71
Hour 10	1533.57	1531.23	0.80	1.54
Hour 11	1511.85	1509.55	0.79	1.51
Hour 12	1329.39	1327.36	0.69	1.33
Hour 13	1142.58	1140.83	0.60	1.14
Hour 14	990.52	989.01	0.52	0.99
Hour 15	1025.28	1023.71	0.54	1.03
Hour 16	1259.87	1257.95	0.66	1.26
Hour 17	1472.75	1470.51	0.77	1.48
Hour 18	1768.17	1765.47	0.92	1.77
Hour 19	2002.77	1999.71	1.05	2.01
Hour 20	1546.60	1544.25	0.81	1.55
Hour 21	1694.31	1691.73	0.88	1.70
Hour 22	1798.58	1795.84	0.94	1.80

Table H-83: Hourly Air Emissions from Microturbine in January (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
TOPP eq.	0.12	0.12	0.13	0.13	0.13	0.17	0.32	0.39	0.39	0.46
SO2 eq.	0.07	0.07	0.07	0.07	0.07	0.10	0.22	0.27	0.27	0.33
SO2	0.01	0.01	0.01	0.01	0.01	0.02	0.06	0.07	0.08	0.09
NOx	0.08	0.08	0.08	0.08	0.09	0.11	0.22	0.27	0.28	0.33
HCl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Particulates	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
CO	0.15	0.15	0.16	0.16	0.16	0.21	0.19	0.18	0.18	0.18
NMVOC	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.03
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.02
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.03	0.03	0.03
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.04	0.04	0.03	0.02	0.00	0.00	0.00	0.00	0.00
0.18	0.18	0.18	0.18	0.18	0.16	0.18	0.14	0.15	0.16
0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
0.38	0.42	0.41	0.35	0.29	0.09	0.09	0.07	0.08	0.08
0.11	0.12	0.12	0.10	0.08	0.02	0.02	0.01	0.01	0.01
0.38	0.42	0.41	0.35	0.28	0.08	0.08	0.06	0.07	0.07
0.52	0.58	0.56	0.48	0.41	0.13	0.14	0.11	0.12	0.13
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-84: Hourly GWP from Microturbine in January (TLF).

Perfluoropentan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobutane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropropane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohexane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocyclobuta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoromethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-10mee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH4	0.61	0.61	0.64	0.67	0.67	0.86	0.72	0.70	0.70
CO2	157.14	158.77	166.10	173.02	174.24	223.91	202.57	202.15	202.02
CO2 Equivalent	169.96	171.72	179.65	187.13	188.46	242.17	218.57	217.90	217.75
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.67	0.65	0.63	0.63	0.66	0.69	0.64	0.72	0.56	0.61	0.65
201.85	201.28	201.01	200.59	201.23	201.75	167.21	187.67	144.93	158.77	168.54
217.35	216.51	216.05	215.64	216.60	217.40	180.84	202.99	156.75	171.72	182.29
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-85: Hourly Primary Energy Consumption from Microturbine in January (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	811.92	811.27	0.36	0.29
Hour 4	820.34	819.67	0.36	0.30
Hour 5	858.20	857.51	0.38	0.31
Hour 6	893.96	893.24	0.40	0.32
Hour 7	900.27	899.54	0.40	0.33
Hour 8	1156.88	1155.95	0.51	0.42
Hour 9	1005.71	988.06	5.99	11.66
Hour 10	987.71	963.59	8.12	16.01
Hour 11	985.23	960.35	8.37	16.52
Hour 12	967.91	936.28	10.58	21.04
Hour 13	948.50	910.13	12.80	25.57
Hour 14	933.56	889.62	14.63	29.31
Hour 15	934.94	892.47	14.15	28.32
Hour 16	958.96	924.99	11.35	22.62
Hour 17	980.50	954.27	8.81	17.42
Hour 18	862.49	861.19	0.58	0.72
Hour 19	969.68	968.90	0.43	0.35
Hour 20	748.82	748.22	0.33	0.27
Hour 21	820.34	819.67	0.36	0.30
Hour 22	870.82	870.12	0.39	0.32

Table H-86: Hourly Air Emissions from 143-kW ICE in January (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
TOPP eq.	0.35	0.35	0.37	0.38	0.38	0.49	0.50	0.54	0.55	0.59
SO2	0.13	0.13	0.13	0.14	0.14	0.18	0.24	0.29	0.29	0.34
SO2	0.01	0.01	0.01	0.01	0.01	0.02	0.05	0.06	0.06	0.08
NOx	0.16	0.16	0.17	0.18	0.18	0.23	0.27	0.31	0.32	0.36
HCl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Particulates	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
CO	1.12	1.13	1.18	1.23	1.24	1.59	1.17	1.06	1.05	0.95
NMVOC	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.60	0.60	0.63	0.66	0.66	0.85	0.61	0.55	0.54	0.47
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.41	0.35	0.37	0.45	0.52	0.63	0.71	0.55	0.60	0.64
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.04	0.04	0.04	0.04	0.03	0.02	0.02	0.01	0.02	0.02
0.84	0.75	0.77	0.90	1.03	1.18	1.34	1.03	1.13	1.20
0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.01
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
0.41	0.45	0.44	0.38	0.33	0.17	0.19	0.15	0.16	0.17
0.10	0.11	0.11	0.09	0.07	0.01	0.02	0.01	0.01	0.01
0.39	0.43	0.42	0.36	0.30	0.13	0.15	0.12	0.13	0.13
0.64	0.68	0.67	0.61	0.56	0.36	0.41	0.32	0.35	0.37
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-87: Hourly GWP Emissions from 143-kW ICE in January (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
CO2 EQ.	153.31	154.90	162.05	168.80	169.99	218.44	189.29	191.66	191.95	194.47
CO2	136.54	137.96	144.33	150.34	151.40	194.56	170.06	173.00	173.37	176.47
CH4	0.73	0.74	0.77	0.80	0.81	1.04	0.82	0.79	0.78	0.75
N2O	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-10mee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoromethan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocyclobu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohexane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropropane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobutane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropentan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.01
0.71	0.68	0.69	0.73	0.77	0.77	0.87	0.67	0.74	0.78
179.15	182.22	181.37	177.66	173.79	143.97	163.07	125.93	137.96	146.45
196.51	199.13	198.37	195.43	192.23	161.65	183.10	141.39	154.90	164.43
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-88: Hourly Primary Energy Consumption from 143-kW ICE in January (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	832.78	832.11	0.37	0.31
Hour 4	841.41	840.73	0.37	0.31
Hour 5	880.25	879.53	0.39	0.33
Hour 6	916.93	916.18	0.41	0.34
Hour 7	923.40	922.65	0.41	0.34
Hour 8	1186.61	1185.64	0.53	0.44
Hour 9	978.82	965.78	4.47	8.58
Hour 10	963.56	943.56	6.75	13.24
Hour 11	961.73	940.88	7.03	13.81
Hour 12	946.47	918.46	9.38	18.62
Hour 13	928.74	893.61	11.73	23.40
Hour 14	918.09	876.80	13.75	27.53
Hour 15	919.90	880.08	13.27	26.55
Hour 16	940.67	909.94	10.28	20.45
Hour 17	957.44	935.16	7.50	14.78
Hour 18	878.09	877.38	0.39	0.32
Hour 19	994.59	993.79	0.44	0.37
Hour 20	768.06	767.44	0.34	0.28
Hour 21	841.41	840.73	0.37	0.31
Hour 22	893.19	892.47	0.40	0.33

Table H-89: Hourly Air Emissions from 3-MW ICE in January (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.60	0.60	0.63	0.66	0.66	0.85	0.61	0.55	0.54	0.47
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOC	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.01
CO	1.38	1.40	1.46	1.52	1.53	1.97	1.41	1.27	1.25	1.10
Particulates	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HCl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOx	0.20	0.20	0.21	0.22	0.22	0.29	0.20	0.18	0.18	0.16
SO2	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
SO2 eq.	0.16	0.16	0.16	0.17	0.17	0.22	0.16	0.14	0.14	0.12
TOPP eq.	0.43	0.43	0.45	0.47	0.47	0.61	0.44	0.39	0.39	0.34

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.41	0.35	0.37	0.45	0.52	0.63	0.71	0.55	0.60	0.64
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02
0.96	0.85	0.87	1.04	1.22	1.46	1.65	1.28	1.40	1.48
0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.18	0.25	0.24	0.15	0.18	0.21	0.24	0.18	0.20	0.21
0.03	0.05	0.04	0.01	0.01	0.02	0.02	0.01	0.02	0.02
0.16	0.23	0.21	0.12	0.14	0.16	0.19	0.14	0.16	0.17
0.36	0.43	0.42	0.32	0.38	0.45	0.51	0.39	0.43	0.46
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-90: Hourly GWP Air Emissions from 3-MW ICE in January (TLF).

Perfluoropentan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobutane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropropane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohexane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocyclobu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoromethan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-10mee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
CH4	0.90	0.91	0.95	0.99	1.00	1.29	0.92	0.83	0.81	0.72
CO2	168.89	170.64	178.52	185.95	187.27	240.65	172.39	154.45	152.26	133.89
CO2 Equivalent	189.63	191.59	200.44	208.79	210.26	270.19	193.56	173.42	170.96	150.33
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01
0.65	0.63	0.63	0.68	0.79	0.95	1.08	0.83	0.91	0.97
128.98	138.33	136.38	126.89	148.33	178.08	201.71	155.76	170.64	181.14
144.07	153.23	151.34	142.47	166.54	199.94	226.47	174.89	191.59	203.38
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-91: Hourly Primary Energy Consumption from 3-MW ICE in January (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	1029.98	1029.12	0.46	0.41
Hour 4	1040.66	1039.78	0.46	0.41
Hour 5	1088.69	1087.77	0.48	0.43
Hour 6	1134.05	1133.10	0.50	0.45
Hour 7	1142.05	1141.10	0.51	0.45
Hour 8	1467.59	1466.36	0.65	0.58
Hour 9	1051.33	1050.45	0.47	0.41
Hour 10	941.93	941.14	0.42	0.37
Hour 11	928.58	927.81	0.41	0.37
Hour 12	816.51	815.83	0.36	0.32
Hour 13	760.14	753.96	2.17	4.02
Hour 14	770.21	754.17	5.41	10.63
Hour 15	768.70	754.84	4.69	9.17
Hour 16	773.82	773.17	0.34	0.30
Hour 17	904.57	903.81	0.40	0.36
Hour 18	1086.02	1085.11	0.48	0.43
Hour 19	1230.11	1229.08	0.55	0.48
Hour 20	949.93	949.14	0.42	0.37
Hour 21	1040.66	1039.78	0.46	0.41
Hour 22	1104.70	1103.77	0.49	0.43

Table H-92: Hourly Air Emissions from SOFC (AC) in May (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
TOPP eq.	0.19	0.18	0.17	0.16	0.21	0.09	0.16	0.18	0.22	0.25
SO2 eq.	0.15	0.14	0.13	0.12	0.16	0.05	0.09	0.09	0.12	0.13
SO2	0.04	0.04	0.04	0.04	0.05	0.00	0.01	0.01	0.01	0.01
NOx	0.14	0.13	0.13	0.12	0.16	0.06	0.11	0.12	0.15	0.17
HCl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Particulates	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
CO	0.04	0.03	0.03	0.03	0.04	0.04	0.07	0.08	0.10	0.11
NMVOC	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.02
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.00	0.00
0.11	0.10	0.10	0.12	0.13	0.12	0.10	0.06	0.03	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.16	0.16	0.16	0.19	0.20	0.19	0.15	0.09	0.04	0.03
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
0.13	0.12	0.12	0.14	0.15	0.14	0.11	0.07	0.03	0.03
0.24	0.24	0.23	0.27	0.29	0.27	0.22	0.14	0.06	0.04
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-93: Hourly GWP from SOFC (AC) in May (TLF).

Perfluoropentan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobutane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropropane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohexane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocyclobutane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoromethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-10mee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH4	0.11	0.11	0.10	0.10	0.12	0.32	0.56	0.62	0.78
CO2	45.77	43.12	40.77	38.41	49.38	119.80	213.69	235.56	294.68
CO2 eq.	48.87	46.04	43.52	41.00	52.72	126.62	225.85	248.96	311.45
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.88	0.83	0.82	0.80	0.95	1.01	0.95	0.75	0.48	0.20	0.10
332.82	315.74	309.26	301.16	357.93	381.42	357.79	283.10	180.09	77.16	38.01
351.76	333.71	326.86	318.30	378.29	403.12	378.15	299.20	190.34	81.55	40.21
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-94: Hourly Primary Energy Consumption from SOFC (AC) in May (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	196.85	180.42	5.44	10.99
Hour 4	185.73	170.37	5.08	10.27
Hour 5	175.85	161.44	4.77	9.64
Hour 6	165.97	152.50	4.46	9.00
Hour 7	211.98	194.10	5.92	11.96
Hour 8	615.20	614.01	0.40	0.78
Hour 9	1097.20	1095.04	0.73	1.43
Hour 10	1209.48	1207.10	0.81	1.57
Hour 11	1513.04	1510.05	1.01	1.98
Hour 12	1708.86	1705.48	1.14	2.23
Hour 13	1621.16	1617.95	1.09	2.12
Hour 14	1587.89	1584.75	1.06	2.07
Hour 15	1546.31	1543.25	1.03	2.02
Hour 16	1837.77	1834.13	1.23	2.40
Hour 17	1958.36	1954.49	1.31	2.56
Hour 18	1837.02	1833.38	1.23	2.41
Hour 19	1453.52	1450.64	0.98	1.91
Hour 20	924.66	922.82	0.62	1.21
Hour 21	396.17	395.39	0.26	0.52
Hour 22	191.63	189.77	0.62	1.24

Table H-95: Hourly Air Emissions from Microturbine (AC) in May (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
TOPP eq.	0.22	0.21	0.20	0.19	0.24	0.43	0.55	0.51	0.40	0.33
SO2	0.17	0.16	0.15	0.14	0.18	0.32	0.40	0.37	0.28	0.23
SO2	0.05	0.05	0.04	0.04	0.05	0.09	0.11	0.10	0.08	0.06
NOx	0.16	0.15	0.15	0.14	0.18	0.32	0.40	0.37	0.29	0.23
HCl	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Particulates	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CO	0.04	0.04	0.04	0.04	0.05	0.12	0.18	0.18	0.19	0.19
NMVOC	0.02	0.01	0.01	0.01	0.02	0.03	0.04	0.03	0.02	0.02
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.03
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.01	0.01
0.19	0.19	0.19	0.19	0.19	0.16	0.13	0.08	0.06	0.05
0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.26	0.27	0.28	0.20	0.17	0.09	0.07	0.05	0.13	0.15
0.07	0.07	0.07	0.05	0.04	0.02	0.01	0.01	0.04	0.05
0.25	0.26	0.27	0.19	0.16	0.08	0.06	0.04	0.13	0.16
0.37	0.38	0.39	0.29	0.25	0.14	0.11	0.07	0.18	0.21
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-96: Hourly GWP Emissions from Microturbine (AC) in May (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Perfluoropen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropro	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocyc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroeth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoromet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
CH4	0.12	0.12	0.11	0.11	0.13	0.43	0.64	0.66	0.70	0.73
CO2	48.96	46.38	43.95	41.60	52.64	140.46	202.18	202.47	203.62	204.37
CO2 Eq.	52.37	49.61	47.02	44.50	56.30	150.87	217.41	217.86	219.45	220.48

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.71	0.71	0.70	0.74	0.76	0.67	0.53	0.34	0.22	0.17
204.34	204.07	203.89	204.77	205.26	173.43	137.23	87.30	68.82	58.24
220.34	220.01	219.78	221.06	221.73	187.55	148.40	94.41	74.03	62.46
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-97: Hourly Primary Energy Consumption from Microturbine (AC) in May (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	207.80	189.06	6.20	12.53
Hour 4	196.99	179.29	5.86	11.84
Hour 5	186.80	170.08	5.54	11.18
Hour 6	176.92	161.14	5.22	10.55
Hour 7	223.24	203.02	6.69	13.52
Hour 8	645.10	611.43	11.20	22.47
Hour 9	947.61	907.01	13.54	27.07
Hour 10	959.02	922.47	12.21	24.35
Hour 11	991.85	966.10	8.65	17.10
Hour 12	1012.70	993.92	6.36	12.42
Hour 13	1004.63	982.60	7.42	14.60
Hour 14	1000.48	977.33	7.80	15.36
Hour 15	996.00	971.37	8.28	16.35
Hour 16	1026.02	1011.87	4.84	9.31
Hour 17	1039.00	1029.13	3.43	6.44
Hour 18	894.35	892.78	0.67	0.90
Hour 19	707.65	706.41	0.53	0.71
Hour 20	450.17	449.38	0.34	0.45
Hour 21	324.61	311.63	4.33	8.65
Hour 22	260.28	243.38	5.61	11.30

Table H-98: Hourly Air Emissions from 143-kW ICE (AC) in May (TLF).

Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.01	0.01	0.01	0.01	0.01	0.22	0.39	0.43	0.54	0.61
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOC	0.02	0.01	0.01	0.01	0.02	0.03	0.04	0.04	0.03	0.03
CO	0.06	0.05	0.05	0.05	0.06	0.48	0.81	0.87	1.05	1.16
Particulates	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HCl	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00
NOx	0.16	0.15	0.15	0.14	0.18	0.33	0.43	0.40	0.33	0.28
SO2	0.05	0.05	0.04	0.04	0.05	0.09	0.11	0.10	0.07	0.05
SO2 eq.	0.17	0.16	0.15	0.14	0.18	0.32	0.41	0.38	0.30	0.25
TOPP eq.	0.22	0.21	0.20	0.19	0.24	0.50	0.66	0.63	0.56	0.51
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.57	0.56	0.55	0.65	0.69	0.65	0.52	0.33	0.14	0.06
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.02
1.11	1.09	1.07	1.24	1.31	1.22	0.97	0.62	0.29	0.15
0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.30	0.31	0.32	0.25	0.22	0.18	0.15	0.09	0.14	0.16
0.06	0.06	0.06	0.04	0.02	0.02	0.01	0.01	0.03	0.04
0.27	0.28	0.29	0.21	0.18	0.14	0.11	0.07	0.13	0.16
0.53	0.54	0.55	0.48	0.45	0.39	0.31	0.19	0.22	0.23
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-99: Hourly GWP Emissions from 143-kW ICE (AC) in May (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Perfluoropentan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobutane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropropane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohexane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocyclobu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoromethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-10mee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
CH4	0.13	0.12	0.11	0.11	0.13	0.46	0.70	0.73	0.79	0.82
CO2	48.42	45.84	43.49	41.13	52.10	128.52	181.40	179.59	175.11	172.07
CO2 eq.	51.87	49.12	46.60	44.08	55.80	140.07	198.70	197.25	193.79	191.39

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
0.81	0.80	0.79	0.85	0.87	0.80	0.63	0.40	0.24	0.18
173.77	174.13	174.76	170.08	168.29	150.97	119.46	75.99	61.33	54.91
192.83	193.07	193.56	189.83	188.44	169.40	134.04	85.27	67.28	59.46
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-100: Hourly Primary Energy Consumption from 143-kW ICE (AC) in May (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	207.20	188.55	6.17	12.47
Hour 4	196.39	178.78	5.83	11.78
Hour 5	186.50	169.84	5.52	11.14
Hour 6	176.62	160.91	5.20	10.51
Hour 7	222.64	202.51	6.67	13.46
Hour 8	634.19	602.29	10.61	21.28
Hour 9	930.32	892.67	12.56	25.09
Hour 10	940.03	906.72	11.13	22.18
Hour 11	968.56	946.82	7.32	14.42
Hour 12	985.96	971.75	4.85	9.36
Hour 13	979.59	961.87	6.00	11.72
Hour 14	975.96	957.02	6.40	12.54
Hour 15	972.19	951.66	6.93	13.60
Hour 16	997.48	988.23	3.22	6.04
Hour 17	1008.56	1003.90	1.70	2.95
Hour 18	917.10	915.51	0.68	0.91
Hour 19	725.66	724.39	0.54	0.72
Hour 20	461.62	460.82	0.34	0.46
Hour 21	318.40	306.48	3.98	7.94
Hour 22	257.52	241.09	5.46	10.98

Table H-101: Hourly Air Emissions from 3-MW ICE (AC) in May (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
TOPP eq.	0.22	0.20	0.19	0.18	0.23	0.35	0.39	0.33	0.39	0.44
SO2 eq.	0.16	0.15	0.14	0.13	0.17	0.20	0.18	0.13	0.15	0.16
SO2	0.05	0.04	0.04	0.04	0.05	0.05	0.04	0.02	0.02	0.02
NOx	0.16	0.15	0.14	0.13	0.17	0.21	0.21	0.16	0.19	0.21
HCl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Particulates	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
CO	0.06	0.06	0.06	0.05	0.06	0.54	0.92	1.00	1.24	1.41
NMVOC	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.01	0.01	0.01	0.01	0.01	0.22	0.39	0.43	0.54	0.61
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.57	0.56	0.55	0.65	0.69	0.65	0.52	0.33	0.14	0.06
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
1.33	1.31	1.27	1.51	1.61	1.51	1.20	0.76	0.33	0.17
0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.01
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.20	0.19	0.19	0.23	0.24	0.23	0.18	0.11	0.06	0.12
0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.03
0.16	0.15	0.15	0.18	0.19	0.18	0.14	0.09	0.05	0.12
0.42	0.41	0.40	0.48	0.51	0.48	0.38	0.24	0.12	0.18
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-102: Hourly GWP from 3-MW (AC) in May (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Perfluoropentan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobutane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropropane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohexane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocyclobu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoromethan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-10mee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01
CH4	0.12	0.12	0.11	0.11	0.13	0.43	0.65	0.66	0.81	0.92
CO2	47.23	44.65	42.30	39.87	50.91	101.99	133.51	126.64	153.38	173.23
CO2 Eq.	50.63	47.87	45.35	42.76	54.56	112.34	148.64	141.90	172.12	194.40

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
0.87	0.86	0.83	0.99	1.05	0.99	0.78	0.50	0.22	0.17
164.34	160.97	156.75	186.30	198.53	186.24	147.36	93.74	43.86	47.17
184.42	180.64	175.91	209.07	222.79	208.99	165.37	105.20	49.02	51.37
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-103: Hourly Primary Energy Consumption from 3-MW ICE (AC) in May (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	203.16	185.19	5.95	12.02
Hour 4	192.35	175.42	5.61	11.32
Hour 5	182.47	166.48	5.29	10.69
Hour 6	172.28	157.27	4.97	10.04
Hour 7	218.60	199.15	6.44	13.01
Hour 8	545.36	528.83	5.54	10.99
Hour 9	769.80	759.77	3.43	6.60
Hour 10	762.36	759.56	1.05	1.75
Hour 11	932.47	931.00	0.64	0.83
Hour 12	1053.15	1051.49	0.72	0.94
Hour 13	999.11	997.53	0.68	0.89
Hour 14	978.60	977.06	0.67	0.87
Hour 15	952.97	951.47	0.65	0.85
Hour 16	1132.60	1130.82	0.77	1.01
Hour 17	1206.93	1205.03	0.83	1.08
Hour 18	1132.17	1130.37	0.78	1.02
Hour 19	895.82	894.40	0.62	0.81
Hour 20	569.87	568.97	0.39	0.51
Hour 21	259.69	257.82	0.66	1.21
Hour 22	231.48	219.50	3.98	8.00

Table H-104: Hourly Air Emissions from SOFC (AC) in August (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOC	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02
CO	0.02	0.02	0.02	0.02	0.02	0.07	0.09	0.11	0.11	0.13
Particulates	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HCl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOx	0.03	0.03	0.03	0.03	0.04	0.11	0.13	0.17	0.16	0.20
SO2	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
SO2 eq.	0.02	0.02	0.02	0.02	0.03	0.08	0.10	0.13	0.13	0.16
TOPP eq.	0.04	0.04	0.05	0.04	0.06	0.16	0.19	0.26	0.24	0.30

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0.01	0.00
0.17	0.18	0.16	0.20	0.20	0.16	0.10	0.08	0.04	0.03
0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.26	0.27	0.25	0.31	0.30	0.24	0.16	0.12	0.06	0.04
0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00
0.20	0.21	0.19	0.24	0.23	0.19	0.12	0.09	0.05	0.03
0.38	0.40	0.37	0.45	0.45	0.36	0.23	0.18	0.09	0.06
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-105: Hourly GWP from SOFC (AC) in August (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Perfluoropen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropro	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocyc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroeth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoromet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH4	0.15	0.15	0.16	0.15	0.19	0.55	0.67	0.89	0.84	1.03
CO2	57.72	58.53	60.96	58.53	72.30	207.28	254.18	335.99	316.55	390.33
CO2 Equivalent	61.00	61.86	64.43	61.86	76.41	219.07	268.65	355.11	334.56	412.54

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.32	1.38	1.28	1.57	1.54	1.24	0.81	0.62	0.33	0.22
499.60	520.66	485.02	596.05	583.91	470.37	307.39	233.55	123.32	84.45
528.03	550.28	512.62	629.97	617.13	497.14	324.89	246.84	130.34	89.25
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-106: Hourly Primary Energy Consumption from SOFC (AC) in August (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	296.36	295.78	0.20	0.38
Hour 4	300.52	299.93	0.20	0.39
Hour 5	313.00	312.38	0.21	0.41
Hour 6	300.52	299.93	0.20	0.39
Hour 7	371.22	370.49	0.25	0.48
Hour 8	1064.30	1062.22	0.71	1.38
Hour 9	1305.12	1302.55	0.87	1.70
Hour 10	1725.12	1721.71	1.16	2.26
Hour 11	1625.32	1622.10	1.09	2.12
Hour 12	2004.10	2000.14	1.34	2.62
Hour 13	2565.12	2560.02	1.72	3.37
Hour 14	2673.24	2667.93	1.80	3.51
Hour 15	2490.27	2485.32	1.67	3.27
Hour 16	3060.34	3054.26	2.06	4.02
Hour 17	2997.96	2992.01	2.02	3.94
Hour 18	2415.04	2410.24	1.62	3.17
Hour 19	1578.27	1575.14	1.06	2.07
Hour 20	1199.11	1196.73	0.81	1.58
Hour 21	633.20	631.94	0.42	0.83
Hour 22	433.59	432.74	0.29	0.57

Table H-107: Hourly Air Emissions from Microturbine (AC) in August (TLF).

Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOC	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.02	0.01
CO	0.05	0.04	0.04	0.04	0.05	0.13	0.18	0.19	0.19	0.19
Particulates	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HCl	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
NOx	0.10	0.09	0.08	0.07	0.09	0.20	0.34	0.23	0.26	0.16
SO2	0.03	0.03	0.02	0.02	0.03	0.05	0.10	0.06	0.07	0.03
SO2 eq.	0.10	0.09	0.08	0.07	0.09	0.19	0.34	0.22	0.25	0.15
TOPPeq.	0.14	0.12	0.11	0.10	0.13	0.28	0.47	0.33	0.36	0.23
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.05	0.05	0.04	0.05	0.05	0.04	0.03	0.02	0.01	0.01
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01
0.23	0.24	0.22	0.27	0.27	0.21	0.14	0.11	0.07	0.06
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.13	0.13	0.12	0.15	0.15	0.12	0.08	0.06	0.07	0.09
0.02	0.02	0.02	0.03	0.03	0.02	0.01	0.01	0.02	0.03
0.11	0.12	0.11	0.13	0.13	0.11	0.07	0.05	0.07	0.09
0.20	0.21	0.19	0.24	0.23	0.19	0.12	0.09	0.10	0.13
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-108: Hourly GWP Emissions from Microturbine (AC) in August (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
CO2 eq.	56.13	53.64	51.22	48.45	61.26	153.00	218.19	220.57	220.22
CO2	52.18	49.85	47.57	44.99	56.90	141.95	202.67	204.44	204.21
CH4	0.17	0.16	0.16	0.15	0.19	0.49	0.67	0.73	0.71
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-10mee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoromethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocyclobutane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohexane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropropane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobutane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropentan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.77	0.93	0.97	0.90	1.11	1.09	0.88	0.57	0.43	0.26	0.21
205.46	242.18	252.39	235.11	288.94	283.05	228.01	149.01	113.21	71.41	61.39
221.99	261.91	272.95	254.26	312.47	306.10	246.59	161.14	122.44	77.08	66.14
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-109: Hourly Primary Energy Consumption from Microturbine (AC) in August (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	245.78	235.79	3.33	6.66
Hour 4	236.38	227.48	2.97	5.93
Hour 5	227.93	220.42	2.51	5.00
Hour 6	215.99	209.05	2.32	4.62
Hour 7	272.32	263.22	3.05	6.06
Hour 8	692.36	674.76	5.91	11.68
Hour 9	968.51	935.43	11.06	22.01
Hour 10	1014.46	996.25	6.17	12.04
Hour 11	1004.49	982.67	7.36	14.46
Hour 12	1043.97	1035.72	2.90	5.35
Hour 13	1248.86	1246.66	0.94	1.26
Hour 14	1301.51	1299.22	0.98	1.31
Hour 15	1212.41	1210.28	0.91	1.22
Hour 16	1489.98	1487.36	1.12	1.50
Hour 17	1459.61	1457.04	1.10	1.47
Hour 18	1175.80	1173.73	0.89	1.19
Hour 19	768.40	767.05	0.58	0.77
Hour 20	583.81	582.78	0.44	0.59
Hour 21	357.10	351.88	1.78	3.44
Hour 22	296.99	288.39	2.88	5.72

Table H-110: Hourly Air Emissions from 143-kW ICE (AC) in August (TLF).

Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.11	0.11	0.11	0.11	0.13	0.38	0.46	0.61	0.58	0.71
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOC	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.03	0.03	0.02
CO	0.22	0.22	0.22	0.21	0.26	0.74	0.93	1.17	1.12	1.34
Particulates	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HCl	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
NOx	0.11	0.10	0.09	0.08	0.10	0.23	0.38	0.28	0.30	0.21
SO2	0.03	0.02	0.02	0.02	0.02	0.05	0.09	0.05	0.06	0.02
SO2 eq.	0.10	0.09	0.08	0.08	0.10	0.21	0.36	0.24	0.27	0.17
TOPP eq.	0.17	0.15	0.14	0.13	0.17	0.39	0.61	0.50	0.53	0.44
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.91	0.95	0.88	1.08	1.06	0.86	0.56	0.43	0.22	0.15
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.03	0.02	0.03	0.03	0.02	0.01	0.01	0.01	0.01
1.71	1.78	1.66	2.04	1.99	1.61	1.05	0.80	0.43	0.30
0.02	0.02	0.02	0.03	0.02	0.02	0.01	0.01	0.01	0.01
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.26	0.27	0.25	0.31	0.30	0.24	0.16	0.12	0.09	0.10
0.02	0.02	0.02	0.03	0.03	0.02	0.01	0.01	0.01	0.02
0.20	0.21	0.20	0.24	0.24	0.19	0.12	0.09	0.08	0.10
0.54	0.56	0.52	0.64	0.63	0.51	0.33	0.25	0.17	0.17
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-111: Hourly GWP Emissions from 143-kW ICE (AC) in August (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
CO2 eq.	51.08	48.47	45.93	43.28	54.92	134.93	196.55	191.25	192.59	187.94
CO2	46.57	44.12	41.68	39.26	49.86	121.87	178.55	171.87	173.52	167.64
CH4	0.18	0.18	0.18	0.17	0.21	0.55	0.75	0.83	0.81	0.88
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-10mee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoromethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocyclobu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohexane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropropane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobutane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropentan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
1.12	1.17	1.09	1.33	1.31	1.05	0.69	0.52	0.29	0.23
210.82	219.71	204.67	251.53	246.40	198.49	129.71	98.56	59.47	53.22
236.55	246.53	229.65	282.23	276.48	222.72	145.55	110.58	66.34	58.78
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-112: Hourly Primary Energy Consumption from 143-kW ICE (AC) in August (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	241.07	231.88	3.07	6.12
Hour 4	231.42	223.34	2.70	5.37
Hour 5	223.26	216.57	2.24	4.45
Hour 6	211.17	205.05	2.05	4.07
Hour 7	266.54	258.44	2.72	5.39
Hour 8	675.80	661.04	4.98	9.79
Hour 9	950.26	920.45	9.98	19.82
Hour 10	987.55	973.94	4.65	8.96
Hour 11	979.11	961.62	5.93	11.56
Hour 12	1012.84	1009.93	1.13	1.78
Hour 13	1280.62	1278.39	0.95	1.28
Hour 14	1334.61	1332.28	0.99	1.33
Hour 15	1243.25	1241.08	0.93	1.24
Hour 16	1527.88	1525.21	1.14	1.53
Hour 17	1496.73	1494.12	1.12	1.50
Hour 18	1205.71	1203.60	0.90	1.21
Hour 19	787.94	786.57	0.59	0.79
Hour 20	598.66	597.61	0.45	0.60
Hour 21	347.31	343.77	1.23	2.32
Hour 22	290.28	282.82	2.50	4.95

Table H-113: Hourly Air Emissions from 3-MW ICE (AC) in August (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cobalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.11	0.11	0.11	0.11	0.13	0.38	0.46	0.61	0.58
Barium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H2S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOC	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.02
CO	0.25	0.25	0.26	0.25	0.31	0.88	1.07	1.42	1.34
Particulates	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02
HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HCl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOx	0.05	0.04	0.04	0.04	0.05	0.13	0.16	0.21	0.20
SO2	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02
SO2 eq.	0.04	0.03	0.03	0.03	0.04	0.10	0.13	0.17	0.16
TOPP e.	0.09	0.08	0.08	0.08	0.10	0.28	0.34	0.45	0.42

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.71	0.91	0.95	0.88	1.08	1.06	0.86	0.56	0.43	0.22	0.15
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.03	0.03	0.03	0.04	0.03	0.03	0.02	0.01	0.01	0.01
1.65	2.11	2.20	2.05	2.52	2.47	1.99	1.30	0.99	0.52	0.36
0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	0.31	0.33	0.31	0.38	0.37	0.30	0.19	0.15	0.08	0.05
0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0.01	0.00
0.19	0.25	0.26	0.24	0.30	0.29	0.23	0.15	0.12	0.06	0.04
0.52	0.67	0.69	0.65	0.79	0.78	0.63	0.41	0.31	0.16	0.11
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-114: Hourly GWP Emissions from 3-MW ICE (AC) in August (TLF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
CO2 eq.	37.37	34.60	35.60	34.18	42.22	121.05	148.46	196.25	184.90	227.99
CO2	33.46	30.85	31.72	30.46	37.63	107.86	132.29	174.88	164.76	203.17
CH4	0.17	0.16	0.17	0.16	0.20	0.57	0.70	0.93	0.88	1.08
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-10mee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorometha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoroethan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorocyclo-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorohexan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropropa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluorobutan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfluoropenta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
1.38	1.44	1.34	1.65	1.61	1.30	0.85	0.65	0.34	0.23
260.06	271.03	252.47	310.28	303.95	244.85	160.01	121.57	64.19	43.95
291.84	304.15	283.32	348.19	341.09	274.77	179.56	136.43	72.04	49.32
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-115: Hourly Primary Energy Consumption from 3-MW ICE (AC) in August (TLF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	197.00	195.34	0.58	1.08
Hour 4	186.86	186.41	0.18	0.27
Hour 5	192.88	192.58	0.13	0.17
Hour 6	185.19	184.91	0.12	0.16
Hour 7	228.77	228.41	0.16	0.20
Hour 8	655.87	654.85	0.44	0.57
Hour 9	804.31	803.05	0.55	0.71
Hour 10	1063.18	1061.50	0.73	0.95
Hour 11	1001.67	1000.09	0.69	0.89
Hour 12	1235.13	1233.17	0.85	1.11
Hour 13	1580.92	1578.41	1.09	1.43
Hour 14	1647.56	1644.94	1.14	1.49
Hour 15	1534.79	1532.35	1.06	1.38
Hour 16	1886.15	1883.14	1.30	1.71
Hour 17	1847.70	1844.76	1.27	1.67
Hour 18	1488.44	1486.07	1.03	1.35
Hour 19	972.71	971.17	0.67	0.88
Hour 20	739.04	737.86	0.51	0.67
Hour 21	390.24	389.62	0.27	0.35
Hour 22	267.21	266.79	0.18	0.24

Electrical Load Following: Hourly Data

Table H-116: Air Emissions from Energy Systems in a Typical Day in January (ELF).

Zinc	4.5E-04	4.5E-04	2.4E-04	9.8E-05	7.2E-05	3.4E-04	3.1E-04
Xylene	0.0E+00	0.0E+00	3.2E-03	3.2E-03	0.0E+00	0.0E+00	0.0E+00
VOC	8.5E-02	8.5E-02	4.5E-02	1.9E-02	1.4E-02	6.4E-02	5.8E-02
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	3.6E-05	3.6E-05	1.9E-05	7.8E-06	5.8E-06	2.7E-05	2.4E-05
Toluene	0.0E+00	0.0E+00	9.0E-03	9.0E-03	0.0E+00	0.0E+00	0.0E+00
TOC	1.7E-01	1.7E-01	1.2E-01	6.3E-02	2.7E-02	1.3E-01	1.2E-01
Selenium	3.7E-07	3.7E-07	1.9E-07	8.1E-08	6.0E-08	2.8E-07	2.5E-07
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	3.2E-05	3.2E-05	1.7E-05	7.1E-06	5.2E-06	2.4E-05	2.2E-05
Molybdenum	1.7E-05	1.7E-05	8.9E-06	3.7E-06	2.7E-06	1.3E-05	1.2E-05
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	4.0E-06	4.0E-06	2.1E-06	8.8E-07	6.5E-07	3.0E-06	2.7E-06
Manganese	5.9E-06	5.9E-06	3.1E-06	1.3E-06	9.5E-07	4.4E-06	4.0E-06
Lead	7.7E-06	7.7E-06	4.1E-06	1.7E-06	1.2E-06	5.8E-06	5.3E-06
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.2E-01	0.0E+00	0.0E+00
Copper	1.3E-05	1.3E-05	6.9E-06	2.9E-06	2.1E-06	9.9E-06	9.0E-06
Cobalt	1.3E-06	1.3E-06	6.8E-07	2.8E-07	2.1E-07	9.7E-07	8.9E-07
Chromium	2.2E-05	2.2E-05	1.1E-05	4.7E-06	3.5E-06	1.6E-05	1.5E-05
Cadmium	1.7E-05	1.7E-05	8.9E-06	3.7E-06	2.7E-06	1.3E-05	1.2E-05
Beryllium	1.9E-07	1.9E-07	9.8E-08	4.1E-08	3.0E-08	1.4E-07	1.3E-07
Benzene	0.0E+00	2.9E-04	6.3E+00	6.3E+00	0.0E+00	0.0E+00	0.0E+00
Barium	7.0E-05	7.0E-05	3.7E-05	1.5E-05	1.1E-05	5.2E-05	4.8E-05
arsenic	3.1E-06	3.1E-06	1.6E-06	6.8E-07	5.0E-07	2.3E-06	2.1E-06
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehyde	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	1.0E-04	9.0E-07	7.4E-07	7.3E-07	7.2E-07	7.2E-07	6.9E-07
H2S	1.1E-05	2.0E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.7E-05
NMVOC	1.2E+00	2.7E-01	3.2E-01	3.3E-01	8.0E-02	2.0E-01	1.8E-01
CO	4.2E+00	3.0E+00	1.6E+01	2.1E+01	3.1E+00	1.5E+00	1.4E+00
Particulates	5.4E-01	2.7E-01	2.6E-01	2.8E-01	6.8E-02	1.4E-01	1.3E-01
HF	1.2E-02	1.1E-03	9.0E-04	9.2E-04	9.2E-04	1.0E-03	9.7E-04
HCl	2.4E-01	1.1E-02	8.8E-03	9.0E-03	9.0E-03	9.2E-03	8.9E-03
NOx	1.2E+01	6.0E+00	2.9E+00	3.2E+00	1.7E+00	1.3E+00	1.2E+00
SO2	3.3E+00	3.5E-01	2.7E-01	2.7E-01	2.8E-01	2.7E-01	2.6E-01
AP	1.2E+01	4.5E+00	2.3E+00	2.5E+00	1.5E+00	1.2E+00	1.1E+00
TOPP	1.6E+01	8.1E+00	5.8E+00	6.8E+00	2.7E+00	2.1E+00	2.0E+00
Option [kg]	Base Case	Base Case	3-MW ICE	143-kW	Microturbi	SOFC	SOFC

Table H-117: GWP Emissions from Energy Systems in a Typical Day in January (ELF).

Option [kg]	Base Case Electric	Base Case NGCC	3-MW ICE	143-kW ICE	Microturbine	SOFC	SOFC 33%
Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclobut	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethane	1.5E-06	1.7E-08	1.5E-08	1.4E-08	1.4E-08	4.1E-06	4.1E-06
Perfluoromethane	1.2E-05	1.4E-07	1.2E-07	1.1E-07	1.1E-07	3.3E-05	3.3E-05
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.8E-01	6.0E-02	7.2E-02	8.9E-02	9.0E-03	1.5E-02	1.4E-02
CH4	1.6E+01	1.6E+01	1.4E+01	1.5E+01	1.3E+01	1.3E+01	1.3E+01
CO2	5.1E+03	3.7E+03	3.0E+03	3.0E+03	3.4E+03	3.4E+03	3.2E+03
CO2 Equivalent	5.5E+03	4.1E+03	3.3E+03	3.3E+03	3.7E+03	3.7E+03	3.5E+03

Table H-118: Primary Energy Consumption from Energy Systems in a Typical Day in January (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Base Case Electric	2.4E+04	2.3E+04	4.1E+02	8.1E+02
Base Case NGCC	2.1E+04	2.1E+04	9.2E+00	7.3E+00
3-MW ICE	1.7E+04	1.7E+04	7.7E+00	6.4E+00
143-kW ICE	1.8E+04	1.8E+04	7.8E+00	6.2E+00
Microturbine	1.8E+04	1.8E+04	7.9E+00	6.1E+00
SOFC	1.8E+04	1.8E+04	8.3E+00	6.1E+00
SOFC 33% thermal	1.7E+04	1.7E+04	8.0E+00	5.9E+00

Table H-119: Air Emissions from Energy Systems (EC) in a Typical Day in May (ELF).

Option [kg]	Base Case Electric	Base Case NGCC	3-MW ICE (EC)	143-kW ICE (EC)	Microturbine (EC)	SOFC (EC)
Zinc	1.5E-05	1.5E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	0.0E+00	0.0E+00	3.8E-03	3.8E-03	0.0E+00	0.0E+00
VOC	2.8E-03	2.8E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	1.2E-06	1.2E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	0.0E+00	0.0E+00	1.1E-02	1.1E-02	0.0E+00	0.0E+00
TOC	5.7E-03	5.7E-03	3.1E-02	3.1E-02	0.0E+00	0.0E+00
Selenium	1.2E-08	1.2E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	1.1E-06	1.1E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenum	5.7E-07	5.7E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	1.3E-07	1.3E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	2.0E-07	2.0E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	2.6E-07	2.6E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.8E-01	0.0E+00
Copper	4.4E-07	4.4E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	4.3E-08	4.3E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	7.2E-07	7.2E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	5.7E-07	5.7E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	6.2E-09	6.2E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	3.4E-04	7.5E+00	7.5E+00	0.0E+00	0.0E+00
Barium	2.3E-06	2.3E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	1.0E-07	1.0E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehyd	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	1.2E-04	5.8E-07	6.3E-07	7.7E-07	8.0E-07	4.9E-07
H2S	6.5E-07	1.2E-05	1.3E-05	1.8E-05	1.8E-05	1.1E-05
NMVOC	1.2E+00	7.5E-02	2.5E-01	3.3E-01	5.4E-02	3.9E-02
CO	3.1E+00	1.7E+00	1.8E+01	2.4E+01	3.4E+00	3.4E-01
Particulates	4.6E-01	1.5E-01	2.2E-01	3.0E-01	5.3E-02	3.5E-02
HF	1.4E-02	6.2E-04	7.1E-04	9.4E-04	9.9E-04	6.8E-04
HCl	2.8E-01	6.1E-03	7.0E-03	9.3E-03	9.7E-03	5.9E-03
NOx	1.2E+01	5.7E+00	2.7E+00	3.5E+00	1.8E+00	4.4E-01
SO2	3.7E+00	2.3E-01	2.1E-01	2.8E-01	3.0E-01	1.7E-01
AP	1.3E+01	4.2E+00	2.1E+00	2.7E+00	1.6E+00	4.8E-01
TOPP	1.7E+01	7.4E+00	5.7E+00	7.6E+00	2.8E+00	7.3E-01

Table H-120: GWP Emissions from Energy Systems (EC) in a Typical Day in May (ELF).

Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclob	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethane	1.7E-06	1.1E-08	1.2E-08	1.5E-08	1.6E-08	4.9E-06
Perfluorometha	1.4E-05	8.4E-08	9.8E-08	1.2E-07	1.3E-07	3.9E-05
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.9E-01	5.5E-02	7.7E-02	1.0E-01	8.0E-03	4.8E-03
CH4	9.0E+00	9.1E+00	1.2E+01	1.6E+01	1.4E+01	8.5E+00
CO2	3.6E+03	2.0E+03	2.2E+03	3.0E+03	3.7E+03	2.1E+03
CO2 Equivalent	3.9E+03	2.2E+03	2.5E+03	3.3E+03	4.0E+03	2.3E+03
Option [kg]	Base Case Electric (EC)	Base Case NGCC (EC)	3-MW ICE (EC)	143-kW ICE (EC)	Microturbine (EC)	SOFC (EC)

Table H-121: Primary Energy Consumption from Energy Systems (EC) in a Typical Day in May (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Base Case Electric (EC)	1.5E+04	1.4E+04	4.7E+02	9.5E+02
Base Case NGCC (EC)	1.2E+04	1.2E+04	5.3E+00	4.5E+00
3-MW ICE (EC)	1.4E+04	1.4E+04	6.1E+00	5.5E+00
143-kW ICE (EC)	1.8E+04	1.8E+04	8.1E+00	6.6E+00
Microturbine (EC)	1.9E+04	1.9E+04	8.4E+00	6.7E+00
SOFC (EC)	1.1E+04	1.1E+04	5.5E+00	4.2E+00

Table H-122: Air Emissions from Energy Systems (AC/EC) in a Typical Day in May (ELF).

Option [kg]	Base Case Electric	Base Case NGCC	3-MW ICE (AC/EC)	143-kW ICE	Microturbine	SOFC (AC/EC)
TOPP	1.7E+01	7.4E+00	4.6E+00	6.0E+00	2.3E+00	6.5E-01
AP	1.3E+01	4.2E+00	1.7E+00	2.2E+00	1.3E+00	4.3E-01
SO2	3.7E+00	2.3E-01	1.7E-01	2.2E-01	2.4E-01	1.5E-01
NOx	1.2E+01	5.7E+00	2.2E+00	2.8E+00	1.4E+00	3.9E-01
HCl	2.8E-01	6.1E-03	5.6E-03	7.4E-03	7.7E-03	5.3E-03
HF	1.4E-02	6.2E-04	5.7E-04	7.5E-04	7.9E-04	6.1E-04
Particulates	4.6E-01	1.5E-01	1.8E-01	2.4E-01	4.2E-02	3.1E-02
CO	3.1E+00	1.7E+00	1.5E+01	2.0E+01	2.7E+00	3.0E-01
NMVOC	1.2E+00	7.5E-02	2.0E-01	2.7E-01	4.3E-02	3.5E-02
H2S	6.5E-07	1.2E-05	1.1E-05	1.4E-05	1.5E-05	9.8E-06
NH3	1.2E-04	5.8E-07	4.9E-07	6.0E-07	6.2E-07	4.2E-07
Acetaldehyde	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	1.0E-07	1.0E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Barium	2.3E-06	2.3E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	3.4E-04	6.1E+00	6.0E+00	0.0E+00	0.0E+00
Beryllium	6.2E-09	6.2E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	5.7E-07	5.7E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	7.2E-07	7.2E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	4.3E-08	4.3E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	4.4E-07	4.4E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-01	0.0E+00
Lead	2.6E-07	2.6E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	2.0E-07	2.0E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	1.3E-07	1.3E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenum	5.7E-07	5.7E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	1.1E-06	1.1E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Selenium	1.2E-08	1.2E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TOC	5.7E-03	5.7E-03	2.5E-02	2.4E-02	0.0E+00	0.0E+00
Toluene	0.0E+00	0.0E+00	8.7E-03	8.6E-03	0.0E+00	0.0E+00
Vanadium	1.2E-06	1.2E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	2.8E-03	2.8E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	0.0E+00	0.0E+00	3.1E-03	3.0E-03	0.0E+00	0.0E+00
Zinc	1.5E-05	1.5E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Table H-123: GWP Emissions from Energy Systems (AC/EC) in a Typical Day in May (ELF).

Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclobu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethane	1.7E-06	1.1E-08	9.7E-09	1.2E-08	1.2E-08	4.4E-06
Perfluoromethan	1.4E-05	8.4E-08	7.7E-08	9.5E-08	9.8E-08	3.5E-05
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.9E-01	5.5E-02	6.2E-02	8.2E-02	6.4E-03	4.3E-03
CH4	9.0E+00	9.1E+00	9.7E+00	1.3E+01	1.1E+01	7.6E+00
CO2	3.6E+03	2.0E+03	1.8E+03	2.4E+03	2.9E+03	1.9E+03
CO2 Equivalent	3.9E+03	2.2E+03	2.0E+03	2.7E+03	3.2E+03	2.1E+03
Option [kg]	Base Case Electric (EC)	Base Case NGCC (EC)	3-MW ICE (AC/EC)	143-kW ICE (AC/EC)	Microturbine (AC/EC)	SOFC (AC/EC)

Table H-124: Primary Energy Consumption from Energy Systems (AC/EC) in a Typical Day in May (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Base Case Electric (EC)	1.5E+04	1.4E+04	4.7E+02	9.5E+02
Base Case NGCC (EC)	1.2E+04	1.2E+04	5.3E+00	4.5E+00
3-MW ICE (AC/EC)	1.1E+04	1.1E+04	4.9E+00	4.3E+00
143-kW ICE (AC/EC)	1.5E+04	1.5E+04	6.4E+00	5.1E+00
Microturbine (AC/EC)	1.5E+04	1.5E+04	6.7E+00	5.3E+00
SOFC (AC/EC)	1.0E+04	1.0E+04	4.9E+00	3.6E+00

Table H-125: Air Emissions from Energy Systems (EC) in a Typical Day in August (ELF).

Option [kg]	Base Case Electric (EC)	Base Case NGCC (EC)	3-MW ICE (EC)	143-kW ICE (EC)	Microturbine (EC)	SOFC (EC)
Zinc	1.5E-05	1.5E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	0.0E+00	0.0E+00	4.2E-03	4.2E-03	0.0E+00	0.0E+00
VOC	2.8E-03	2.8E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	1.2E-06	1.2E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	0.0E+00	0.0E+00	1.2E-02	1.2E-02	0.0E+00	0.0E+00
TOC	5.7E-03	5.7E-03	3.4E-02	3.4E-02	0.0E+00	0.0E+00
Selenium	1.2E-08	1.2E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	1.1E-06	1.1E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenu	5.7E-07	5.7E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	1.3E-07	1.3E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	2.0E-07	2.0E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	2.6E-07	2.6E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.3E-01	0.0E+00
Copper	4.4E-07	4.4E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	4.3E-08	4.3E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	7.2E-07	7.2E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	5.7E-07	5.7E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	6.2E-09	6.2E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	3.9E-04	8.5E+00	8.5E+00	0.0E+00	0.0E+00
Barium	2.3E-06	2.3E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	1.0E-07	1.0E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehyd	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	1.3E-04	6.7E-07	7.2E-07	8.8E-07	9.1E-07	5.6E-07
H2S	6.8E-07	1.3E-05	1.5E-05	2.0E-05	2.1E-05	1.2E-05
NMVOC	1.3E+00	8.3E-02	2.8E-01	3.8E-01	6.0E-02	4.4E-02
CO	3.5E+00	1.9E+00	2.1E+01	2.7E+01	3.9E+00	3.9E-01
Particulates	5.2E-01	1.6E-01	2.5E-01	3.3E-01	6.0E-02	4.0E-02
HF	1.6E-02	7.0E-04	8.0E-04	1.1E-03	1.1E-03	7.7E-04
HCl	3.1E-01	6.8E-03	7.8E-03	1.0E-02	1.1E-02	6.7E-03
NOx	1.4E+01	6.4E+00	3.0E+00	4.0E+00	2.0E+00	4.9E-01
SO2	4.2E+00	2.5E-01	2.4E-01	3.1E-01	3.4E-01	1.9E-01
AP	1.4E+01	4.7E+00	2.3E+00	3.1E+00	1.8E+00	5.4E-01
TOPP	1.9E+01	8.3E+00	6.4E+00	8.5E+00	3.2E+00	8.2E-01

Table 126: GWP Emissions from Energy Systems (EC) in a Typical Day in August (ELF).

Option [kg]	Base Case Electric (EC)	Base Case NGCC (EC)	3-MW ICE (EC)	143-kW ICE (EC)	Microturbine (EC)	SOFC (EC)
Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclobut	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethane	1.9E-06	1.2E-08	1.4E-08	1.7E-08	1.8E-08	5.5E-06
Perfluoromethane	1.5E-05	9.6E-08	1.1E-07	1.4E-07	1.4E-07	4.4E-05
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	2.2E-01	6.1E-02	8.6E-02	1.1E-01	9.0E-03	5.4E-03
CH4	1.0E+01	1.0E+01	1.3E+01	1.8E+01	1.6E+01	9.5E+00
CO2	4.0E+03	2.2E+03	2.5E+03	3.4E+03	4.1E+03	2.4E+03
CO2 Equivalent	4.3E+03	2.4E+03	2.8E+03	3.8E+03	4.5E+03	2.6E+03

Table H-127: Primary Energy Consumption from Energy Systems (EC) in a Typical Day in August (ELF).

Option [kWh]	Energy	non renewable	renewable	other
Base Case Electric (EC)	1.7E+04	1.5E+04	5.3E+02	1.1E+03
Base Case NGCC (EC)	1.3E+04	1.3E+04	6.0E+00	5.1E+00
3-MW ICE (EC)	1.5E+04	1.5E+04	6.8E+00	6.2E+00
143-kW ICE (EC)	2.0E+04	2.0E+04	9.1E+00	7.4E+00
Microturbine (EC)	2.1E+04	2.1E+04	9.5E+00	7.7E+00
SOFC (EC)	1.3E+04	1.3E+04	6.2E+00	4.7E+00

Table H-128: Air Emissions from Energy Systems (AC/EC) in a Typical Day in August (ELF).

Option [kg]	Base Case Electric	Base Case NGCC	3-MW ICE (AC/EC)	143-kW ICE	Microturbine (AC/EC)	SOFC (AC/EC)	SOFC 33%
Zinc	1.5E-05	1.5E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	0.0E+00	0.0E+00	3.4E-03	3.0E-03	0.0E+00	0.0E+00	0.0E+00
VOC	2.8E-03	2.8E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	1.2E-06	1.2E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	0.0E+00	0.0E+00	9.8E-03	8.7E-03	0.0E+00	0.0E+00	0.0E+00
TOC	5.7E-03	5.7E-03	2.8E-02	2.5E-02	0.0E+00	0.0E+00	0.0E+00
Selenium	1.2E-08	1.2E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	1.1E-06	1.1E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenum	5.7E-07	5.7E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	1.3E-07	1.3E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	2.0E-07	2.0E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	2.6E-07	2.6E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.1E-01	0.0E+00	0.0E+00
Copper	4.4E-07	4.4E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	4.3E-08	4.3E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	7.2E-07	7.2E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	5.7E-07	5.7E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	6.2E-09	6.2E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	3.9E-04	6.9E+00	6.1E+00	0.0E+00	0.0E+00	0.0E+00
Barium	2.3E-06	2.3E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	1.0E-07	1.0E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehyde	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	1.3E-04	6.7E-07	5.5E-07	6.1E-07	6.3E-07	4.7E-07	4.6E-07
H2S	6.8E-07	1.3E-05	1.2E-05	1.4E-05	1.5E-05	1.1E-05	1.1E-05
NMVOC	1.3E+00	8.3E-02	2.3E-01	2.7E-01	4.3E-02	4.0E-02	3.9E-02
CO	3.5E+00	1.9E+00	1.7E+01	2.0E+01	2.8E+00	3.4E-01	3.3E-01
Particulates	5.2E-01	1.6E-01	2.0E-01	2.4E-01	4.2E-02	3.5E-02	3.4E-02
HF	1.6E-02	7.0E-04	6.5E-04	7.6E-04	8.0E-04	6.9E-04	6.7E-04
HCl	3.1E-01	6.8E-03	6.3E-03	7.5E-03	7.8E-03	6.0E-03	5.9E-03
NOx	1.4E+01	6.4E+00	2.4E+00	2.9E+00	1.5E+00	4.4E-01	4.3E-01
SO2	4.2E+00	2.5E-01	1.9E-01	2.2E-01	2.4E-01	1.7E-01	1.7E-01
AP	1.4E+01	4.7E+00	1.9E+00	2.2E+00	1.3E+00	4.8E-01	4.7E-01
TOPP	1.9E+01	8.3E+00	5.2E+00	6.1E+00	2.3E+00	7.3E-01	7.1E-01

Table H-129: GWP Emissions from Energy Systems (AC/EC) in a Typical Day in August (ELF).

Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclob	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethane	1.9E-06	1.2E-08	1.1E-08	1.2E-08	1.3E-08	4.9E-06	4.8E-06
Perfluoromethan	1.5E-05	9.6E-08	8.7E-08	9.6E-08	9.9E-08	3.9E-05	3.8E-05
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	2.2E-01	6.1E-02	7.0E-02	8.2E-02	6.4E-03	4.8E-03	4.7E-03
CH4	1.0E+01	1.0E+01	1.1E+01	1.3E+01	1.1E+01	8.5E+00	8.3E+00
CO2	4.0E+03	2.2E+03	2.0E+03	2.4E+03	3.0E+03	2.2E+03	2.1E+03
CO2 Equivalent	4.3E+03	2.4E+03	2.3E+03	2.7E+03	3.2E+03	2.4E+03	2.3E+03
Option [kg]	Base Case Electric (EC)	Base Case NGCC (EC)	3-MW ICE (AC/EC)	143-kW ICE (AC/EC)	Microturbine (AC/EC)	SOFC (AC/EC)	SOFC 33% thermal

Table H-130: Primary Energy Consumption from Energy Systems (AC/EC) in a Typical Day in August (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Base Case Electric (EC)	1.7E+04	1.5E+04	5.3E+02	1.1E+03
Base Case NGCC (EC)	1.3E+04	1.3E+04	6.0E+00	5.1E+00
3-MW ICE (AC/EC)	1.2E+04	1.2E+04	5.5E+00	4.9E+00
143-kW ICE (AC/EC)	1.5E+04	1.5E+04	6.5E+00	5.2E+00
Microturbine (AC/EC)	1.5E+04	1.5E+04	6.8E+00	5.3E+00
SOFC (AC/EC)	1.1E+04	1.1E+04	5.5E+00	4.1E+00
SOFC 33% thermal	1.1E+04	1.1E+04	5.4E+00	4.0E+00

Electrical Load Following: Hourly Data

Table H-131: Hourly Air Emissions from SOFC in a Typical Day in January (ELF).

Zinc	1.68E-05	1.71E-05	1.81E-05	1.90E-05	1.87E-05	2.21E-05	1.21E-05	1.01E-05	9.86E-06
Xylene	0	0	0	0	0	0	0	0	0
VOC	3.20E-03	3.25E-03	3.43E-03	3.60E-03	3.55E-03	4.19E-03	2.30E-03	1.92E-03	1.87E-03
VOC	0	0	0	0	0	0	0	0	0
Vanadium	1.35E-06	1.37E-06	1.45E-06	1.52E-06	1.50E-06	1.77E-06	9.71E-07	8.08E-07	7.88E-07
Toluene	0	0	0	0	0	0	0	0	0
TOC	6.40E-03	6.52E-03	6.87E-03	7.21E-03	7.12E-03	8.40E-03	4.61E-03	3.84E-03	3.75E-03
Selenium	1.39E-08	1.42E-08	1.50E-08	1.57E-08	1.55E-08	1.83E-08	1.00E-08	8.36E-09	8.16E-09
PAH	0	0	0	0	0	0	0	0	0
Nickel	1.22E-06	1.24E-06	1.31E-06	1.38E-06	1.36E-06	1.60E-06	8.80E-07	7.33E-07	7.15E-07
Molybdenum	6.40E-07	6.52E-07	6.87E-07	7.21E-07	7.12E-07	8.40E-07	4.61E-07	3.84E-07	3.75E-07
Methane	0	0	0	0	0	0	0	0	0
Mercury	1.51E-07	1.54E-07	1.63E-07	1.71E-07	1.68E-07	1.99E-07	1.09E-07	9.08E-08	8.86E-08
Manganese	2.21E-07	2.25E-07	2.37E-07	2.49E-07	2.46E-07	2.90E-07	1.59E-07	1.33E-07	1.29E-07
Lead	2.91E-07	2.96E-07	3.12E-07	3.27E-07	3.23E-07	3.81E-07	2.09E-07	1.74E-07	1.70E-07
HC	0	0	0	0	0	0	0	0	0
Copper	4.94E-07	5.03E-07	5.30E-07	5.56E-07	5.49E-07	6.48E-07	3.56E-07	2.96E-07	2.89E-07
Cobalt	4.89E-08	4.97E-08	5.25E-08	5.50E-08	5.43E-08	6.41E-08	3.52E-08	2.93E-08	2.86E-08
Chromium	8.12E-07	8.27E-07	8.72E-07	9.15E-07	9.03E-07	1.07E-06	5.85E-07	4.87E-07	4.76E-07
Cadmium	6.40E-07	6.52E-07	6.87E-07	7.21E-07	7.12E-07	8.40E-07	4.61E-07	3.84E-07	3.75E-07
Beryllium	7.00E-09	7.12E-09	7.51E-09	7.88E-09	7.78E-09	9.18E-09	5.04E-09	4.20E-09	4.10E-09
Benzene	0	0	0	0	0	0	0	0	0
Barium	2.63E-06	2.67E-06	2.82E-06	2.96E-06	2.92E-06	3.45E-06	1.89E-06	1.58E-06	1.54E-06
arsenic	1.16E-07	1.18E-07	1.25E-07	1.31E-07	1.29E-07	1.52E-07	8.38E-08	6.97E-08	6.80E-08
Acrolein	0	0	0	0	0	0	0	0	0
Acetaldehyde	0	0	0	0	0	0	0	0	0
NH3	2.46E-08	2.45E-08	2.52E-08	2.58E-08	2.71E-08	3.98E-08	3.77E-08	3.57E-08	3.53E-08
H2S	5.91E-07	5.89E-07	6.07E-07	6.22E-07	6.51E-07	9.52E-07	8.95E-07	8.46E-07	8.41E-07
NMVOC	8.80E-03	8.91E-03	9.35E-03	9.75E-03	9.76E-03	1.22E-02	8.03E-03	7.05E-03	6.93E-03
CO	6.53E-02	6.61E-02	6.93E-02	7.22E-02	7.24E-02	9.11E-02	6.16E-02	5.44E-02	5.35E-02
Particulates	6.15E-03	6.22E-03	6.52E-03	6.79E-03	6.82E-03	8.63E-03	5.92E-03	5.25E-03	5.17E-03
HF	3.33E-05	3.31E-05	3.41E-05	3.48E-05	3.67E-05	5.48E-05	5.32E-05	5.06E-05	5.03E-05
HCl	3.15E-04	3.13E-04	3.23E-04	3.31E-04	3.47E-04	5.09E-04	4.82E-04	4.56E-04	4.53E-04
NOx	5.24E-02	5.28E-02	5.52E-02	5.73E-02	5.81E-02	7.58E-02	5.64E-02	5.10E-02	5.04E-02
SO2	9.26E-03	9.24E-03	9.52E-03	9.75E-03	1.02E-02	1.49E-02	1.40E-02	1.32E-02	1.31E-02
SO2 eq.	4.61E-02	4.64E-02	4.83E-02	5.00E-02	5.10E-02	6.82E-02	5.38E-02	4.92E-02	4.86E-02
TOPP eq.	8.63E-02	8.70E-02	9.09E-02	9.43E-02	9.56E-02	1.25E-01	9.34E-02	8.44E-02	8.34E-02
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

7.78E-06	5.65E-06	3.91E-06	4.31E-06	6.98E-06	9.41E-06	1.41E-05	1.81E-05	1.46E-05	1.65E-05	1.79E-05
0	0	0	0	0	0	0	0	0	0	0
1.48E-03	1.07E-03	7.43E-04	8.18E-04	1.33E-03	1.79E-03	2.67E-03	3.43E-03	2.77E-03	3.13E-03	3.40E-03
0	0	0	0	0	0	0	0	0	0	0
6.22E-07	4.52E-07	3.13E-07	3.45E-07	5.59E-07	7.53E-07	1.13E-06	1.45E-06	1.17E-06	1.32E-06	1.43E-06
0	0	0	0	0	0	0	0	0	0	0
2.96E-03	2.15E-03	1.49E-03	1.64E-03	2.66E-03	3.58E-03	5.35E-03	6.87E-03	5.56E-03	6.27E-03	6.82E-03
6.43E-09	4.67E-09	3.24E-09	3.57E-09	5.78E-09	7.79E-09	1.16E-08	1.50E-08	1.21E-08	1.36E-08	1.48E-08
0	0	0	0	0	0	0	0	0	0	0
5.64E-07	4.10E-07	2.84E-07	3.13E-07	5.06E-07	6.83E-07	1.02E-06	1.31E-06	1.06E-06	1.20E-06	1.30E-06
2.96E-07	2.15E-07	1.49E-07	1.64E-07	2.66E-07	3.58E-07	5.35E-07	6.87E-07	5.56E-07	6.27E-07	6.82E-07
0	0	0	0	0	0	0	0	0	0	0
6.99E-08	5.08E-08	3.52E-08	3.87E-08	6.28E-08	8.46E-08	1.26E-07	1.63E-07	1.31E-07	1.48E-07	1.61E-07
1.02E-07	7.42E-08	5.14E-08	5.66E-08	9.17E-08	1.24E-07	1.85E-07	2.37E-07	1.92E-07	2.17E-07	2.35E-07
1.34E-07	9.74E-08	6.75E-08	7.44E-08	1.21E-07	1.62E-07	2.43E-07	3.12E-07	2.52E-07	2.85E-07	3.09E-07
0	0	0	0	0	0	0	0	0	0	0
2.28E-07	1.66E-07	1.15E-07	1.26E-07	2.05E-07	2.76E-07	4.13E-07	5.30E-07	4.29E-07	4.84E-07	5.26E-07
2.26E-08	1.64E-08	1.14E-08	1.25E-08	2.03E-08	2.73E-08	4.08E-08	5.25E-08	4.24E-08	4.79E-08	5.20E-08
3.75E-07	2.72E-07	1.89E-07	2.08E-07	3.37E-07	4.54E-07	6.79E-07	8.72E-07	7.05E-07	7.96E-07	8.65E-07
2.96E-07	2.15E-07	1.49E-07	1.64E-07	2.66E-07	3.58E-07	5.35E-07	6.87E-07	5.56E-07	6.27E-07	6.82E-07
3.23E-09	2.35E-09	1.63E-09	1.79E-09	2.90E-09	3.91E-09	5.84E-09	7.51E-09	6.07E-09	6.85E-09	7.45E-09
0	0	0	0	0	0	0	0	0	0	0
1.21E-06	8.81E-07	6.10E-07	6.72E-07	1.09E-06	1.47E-06	2.19E-06	2.82E-06	2.28E-06	2.57E-06	2.80E-06
5.37E-08	3.90E-08	2.70E-08	2.97E-08	4.82E-08	6.50E-08	9.71E-08	1.25E-07	1.01E-07	1.14E-07	1.24E-07
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
3.33E-08	3.13E-08	2.95E-08	2.99E-08	3.25E-08	3.49E-08	3.50E-08	3.44E-08	2.51E-08	2.61E-08	2.67E-08
7.91E-07	7.39E-07	6.98E-07	7.07E-07	7.72E-07	8.30E-07	8.34E-07	8.22E-07	6.00E-07	6.27E-07	6.41E-07
5.92E-03	4.90E-03	4.06E-03	4.25E-03	5.54E-03	6.71E-03	8.57E-03	1.01E-02	7.95E-03	8.79E-03	9.41E-03
4.61E-02	3.86E-02	3.25E-02	3.39E-02	4.33E-02	5.19E-02	6.51E-02	7.59E-02	5.94E-02	6.55E-02	6.99E-02
4.48E-03	3.78E-03	3.21E-03	3.34E-03	4.22E-03	5.02E-03	6.22E-03	7.20E-03	5.61E-03	6.18E-03	6.59E-03
4.76E-05	4.49E-05	4.26E-05	4.31E-05	4.66E-05	4.97E-05	4.90E-05	4.75E-05	3.44E-05	3.57E-05	3.63E-05
4.27E-04	4.00E-04	3.78E-04	3.83E-04	4.17E-04	4.48E-04	4.48E-04	4.40E-04	3.21E-04	3.35E-04	3.42E-04
4.48E-02	3.91E-02	3.45E-02	3.55E-02	4.27E-02	4.92E-02	5.73E-02	6.38E-02	4.90E-02	5.33E-02	5.63E-02
1.23E-02	1.15E-02	1.09E-02	1.10E-02	1.20E-02	1.29E-02	1.30E-02	1.29E-02	9.40E-03	9.83E-03	1.01E-02
4.40E-02	3.92E-02	3.53E-02	3.62E-02	4.22E-02	4.76E-02	5.34E-02	5.77E-02	4.38E-02	4.73E-02	4.96E-02
7.42E-02	6.49E-02	5.73E-02	5.90E-02	7.07E-02	8.14E-02	9.47E-02	1.05E-01	8.07E-02	8.78E-02	9.28E-02
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-132: Hourly GWP Emissions from SOFC in a Typical Day in January (ELF).

Option [kg]	CO2 eq.	CO2	CH4	N2O
Hour 3	1.26E+02	1.16E+02	4.58E-01	6.28E-04
Hour 4	1.26E+02	1.16E+02	4.57E-01	6.34E-04
Hour 5	1.29E+02	1.19E+02	4.71E-01	6.62E-04
Hour 6	1.33E+02	1.22E+02	4.82E-01	6.88E-04
Hour 7	1.39E+02	1.28E+02	5.05E-01	6.96E-04
Hour 8	2.03E+02	1.87E+02	7.38E-01	9.01E-04
Hour 9	1.91E+02	1.76E+02	6.93E-01	6.58E-04
Hour 10	1.80E+02	1.66E+02	6.56E-01	5.92E-04
Hour 11	1.79E+02	1.65E+02	6.51E-01	5.84E-04
Hour 12	1.68E+02	1.55E+02	6.12E-01	5.16E-04
Hour 13	1.57E+02	1.45E+02	5.73E-01	4.47E-04
Hour 14	1.49E+02	1.37E+02	5.40E-01	3.91E-04
Hour 15	1.51E+02	1.39E+02	5.48E-01	4.04E-04
Hour 16	1.64E+02	1.52E+02	5.97E-01	4.90E-04
Hour 17	1.77E+02	1.63E+02	6.43E-01	5.69E-04
Hour 18	1.78E+02	1.64E+02	6.46E-01	6.73E-04
Hour 19	1.75E+02	1.62E+02	6.37E-01	7.56E-04
Hour 20	1.28E+02	1.18E+02	4.65E-01	5.83E-04
Hour 21	1.34E+02	1.23E+02	4.86E-01	6.36E-04
Hour 22	1.37E+02	1.26E+02	4.97E-01	6.74E-04

Table H-133: Hourly Primary Energy Consumption from SOFC in a Typical Day in January (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	6.13E+02	6.12E+02	2.79E-01	2.07E-01
Hour 4	6.11E+02	6.10E+02	2.78E-01	2.06E-01
Hour 5	6.29E+02	6.29E+02	2.86E-01	2.12E-01
Hour 6	6.45E+02	6.44E+02	2.92E-01	2.17E-01
Hour 7	6.76E+02	6.75E+02	3.07E-01	2.28E-01
Hour 8	9.88E+02	9.87E+02	4.55E-01	3.36E-01
Hour 9	9.29E+02	9.28E+02	4.37E-01	3.22E-01
Hour 10	8.79E+02	8.78E+02	4.14E-01	3.05E-01
Hour 11	8.72E+02	8.72E+02	4.12E-01	3.03E-01
Hour 12	8.21E+02	8.20E+02	3.89E-01	2.86E-01
Hour 13	7.68E+02	7.67E+02	3.65E-01	2.69E-01
Hour 14	7.24E+02	7.24E+02	3.46E-01	2.54E-01
Hour 15	7.34E+02	7.34E+02	3.51E-01	2.58E-01
Hour 16	8.01E+02	8.00E+02	3.80E-01	2.79E-01
Hour 17	8.61E+02	8.61E+02	4.07E-01	2.99E-01
Hour 18	8.65E+02	8.65E+02	4.04E-01	2.98E-01
Hour 19	8.53E+02	8.53E+02	3.94E-01	2.91E-01
Hour 20	6.22E+02	6.22E+02	2.86E-01	2.12E-01
Hour 21	6.51E+02	6.50E+02	2.97E-01	2.20E-01
Hour 22	6.65E+02	6.65E+02	3.03E-01	2.25E-01

Table H-134: Hourly Air Emissions from Microturbine in a Typical Day in January (ELF).

Zinc	1.15E-05	1.20E-05	1.31E-05	1.42E-05	1.29E-05	1.00E-05	0.00E+0	0	0	0
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	2.18E-03	2.28E-03	2.49E-03	2.69E-03	2.45E-03	1.90E-03	0.00E+0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
Vanadiu	9.19E-07	9.59E-07	1.05E-06	1.13E-06	1.03E-06	8.00E-07	0.00E+0	0	0	0
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	4.37E-03	4.56E-03	4.99E-03	5.39E-03	4.92E-03	3.80E-03	0.00E+0	0	0	0
Selenium	9.51E-09	9.92E-09	1.09E-08	1.17E-08	1.07E-08	8.28E-09	0.00E+0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	8.33E-07	8.69E-07	9.52E-07	1.03E-06	9.38E-07	7.26E-07	0.00E+0	0	0	0
Molybde	4.37E-07	4.56E-07	4.99E-07	5.39E-07	4.92E-07	3.80E-07	0.00E+0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	1.03E-07	1.08E-07	1.18E-07	1.27E-07	1.16E-07	8.99E-08	0.00E+0	0	0	0
Mangane	1.51E-07	1.57E-07	1.72E-07	1.86E-07	1.70E-07	1.31E-07	0.00E+0	0	0	0
Lead	1.98E-07	2.07E-07	2.26E-07	2.44E-07	2.23E-07	1.73E-07	0.00E+0	0	0	0
HC	6.44E-03	6.13E-03	5.97E-03	5.74E-03	6.98E-03	1.46E-02	2.09E-02	2.09E-02	2.09E-02	2.09E-02
Copper	3.37E-07	3.52E-07	3.85E-07	4.16E-07	3.79E-07	2.93E-07	0.00E+0	0	0	0
Cobalt	3.33E-08	3.48E-08	3.81E-08	4.11E-08	3.75E-08	2.90E-08	0.00E+0	0	0	0
Chromiu	5.54E-07	5.78E-07	6.33E-07	6.83E-07	6.24E-07	4.83E-07	0.00E+0	0	0	0
Cadmiu	4.37E-07	4.56E-07	4.99E-07	5.39E-07	4.92E-07	3.80E-07	0.00E+0	0	0	0
Beryllu	4.77E-09	4.98E-09	5.45E-09	5.89E-09	5.37E-09	4.16E-09	0.00E+0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0
Barium	1.79E-06	1.87E-06	2.05E-06	2.21E-06	2.02E-06	1.56E-06	0.00E+0	0	0	0
arsenic	7.93E-08	8.27E-08	9.06E-08	9.78E-08	8.92E-08	6.91E-08	0.00E+0	0	0	0
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetalde	0	0	0	0	0	0	0	0	0	0
NH3	2.47E-08	2.45E-08	2.53E-08	2.59E-08	2.72E-08	3.99E-08	4.31E-08	4.31E-08	4.31E-08	4.31E-08
H2S	5.89E-07	5.85E-07	6.05E-07	6.19E-07	6.49E-07	9.49E-07	1.01E-06	1.01E-06	1.01E-06	1.01E-06
NMVOC	6.46E-03	6.66E-03	7.18E-03	7.65E-03	7.23E-03	6.90E-03	2.96E-03	2.96E-03	2.96E-03	2.96E-03
CO	9.92E-02	9.81E-02	1.01E-01	1.02E-01	1.09E-01	1.68E-01	1.90E-01	1.90E-01	1.90E-01	1.90E-01
Particulat	4.69E-03	4.81E-03	5.16E-03	5.48E-03	5.24E-03	5.33E-03	2.90E-03	2.90E-03	2.90E-03	2.90E-03
HF	3.17E-05	3.15E-05	3.25E-05	3.33E-05	3.49E-05	5.10E-05	5.45E-05	5.45E-05	5.45E-05	5.45E-05
HCl	3.11E-04	3.09E-04	3.19E-04	3.27E-04	3.43E-04	5.01E-04	5.35E-04	5.35E-04	5.35E-04	5.35E-04
NOx	6.15E-02	6.13E-02	6.36E-02	6.53E-02	6.79E-02	9.65E-02	9.97E-02	9.97E-02	9.97E-02	9.97E-02
SO2	9.48E-03	9.42E-03	9.73E-03	9.94E-03	1.05E-02	1.54E-02	1.66E-02	1.66E-02	1.66E-02	1.66E-02
SO2 eq.	5.26E-02	5.24E-02	5.44E-02	5.57E-02	5.81E-02	8.31E-02	8.66E-02	8.66E-02	8.66E-02	8.66E-02
TOPP eq.	9.88E-02	9.86E-02	1.02E-01	1.05E-01	1.09E-01	1.53E-01	1.56E-01	1.56E-01	1.56E-01	1.56E-01
Option	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0	0	0	0	0	0.00E+0	6.93E-06	7.43E-06	9.86E-06	1.19E-05
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	1.32E-03	1.41E-03	1.87E-03	2.26E-03
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	5.55E-07	5.94E-07	7.88E-07	9.51E-07
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	2.64E-03	2.83E-03	3.75E-03	4.52E-03
0	0	0	0	0	0.00E+0	5.74E-09	6.15E-09	8.16E-09	9.84E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	5.03E-07	5.39E-07	7.15E-07	8.62E-07
0	0	0	0	0	0.00E+0	2.64E-07	2.83E-07	3.75E-07	4.52E-07
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	6.23E-08	6.68E-08	8.86E-08	1.07E-07
0	0	0	0	0	0.00E+0	9.11E-08	9.76E-08	1.29E-07	1.56E-07
0	0	0	0	0	0.00E+0	1.20E-07	1.28E-07	1.70E-07	2.05E-07
2.09E-02	2.09E-02	2.09E-02	2.09E-02	2.09E-02	1.71E-02	1.34E-02	8.61E-03	7.99E-03	7.29E-03
0	0	0	0	0	0.00E+0	2.03E-07	2.18E-07	2.89E-07	3.49E-07
0	0	0	0	0	0.00E+0	2.01E-08	2.16E-08	2.86E-08	3.45E-08
0	0	0	0	0	0.00E+0	3.35E-07	3.58E-07	4.76E-07	5.74E-07
0	0	0	0	0	0.00E+0	2.64E-07	2.83E-07	3.75E-07	4.52E-07
0	0	0	0	0	0.00E+0	2.88E-09	3.09E-09	4.10E-09	4.94E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	1.08E-06	1.16E-06	1.54E-06	1.85E-06
0	0	0	0	0	0.00E+0	4.79E-08	5.13E-08	6.80E-08	8.21E-08
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4.31E-08	4.31E-08	4.31E-08	4.31E-08	4.31E-08	3.54E-08	3.45E-08	2.51E-08	2.62E-08	2.68E-08
1.01E-06	1.01E-06	1.01E-06	1.01E-06	1.01E-06	8.33E-07	8.18E-07	5.97E-07	6.25E-07	6.40E-07
2.96E-03	2.96E-03	2.96E-03	2.96E-03	2.96E-03	2.43E-03	5.25E-03	4.81E-03	5.89E-03	6.77E-03
1.90E-01	1.90E-01	1.90E-01	1.90E-01	1.90E-01	1.56E-01	1.46E-01	1.05E-01	1.07E-01	1.08E-01
2.90E-03	2.90E-03	2.90E-03	2.90E-03	2.90E-03	2.38E-03	4.16E-03	3.65E-03	4.37E-03	4.94E-03
5.45E-05	5.45E-05	5.45E-05	5.45E-05	5.45E-05	4.47E-05	4.40E-05	3.21E-05	3.36E-05	3.44E-05
5.35E-04	5.35E-04	5.35E-04	5.35E-04	5.35E-04	4.39E-04	4.32E-04	3.15E-04	3.30E-04	3.38E-04
9.97E-02	9.97E-02	9.97E-02	9.97E-02	9.97E-02	8.19E-02	8.27E-02	6.10E-02	6.45E-02	6.66E-02
1.66E-02	1.66E-02	1.66E-02	1.66E-02	1.66E-02	1.37E-02	1.33E-02	9.68E-03	1.01E-02	1.03E-02
8.66E-02	8.66E-02	8.66E-02	8.66E-02	8.66E-02	7.12E-02	7.13E-02	5.25E-02	5.54E-02	5.71E-02
1.56E-01	1.56E-01	1.56E-01	1.56E-01	1.56E-01	1.29E-01	1.31E-01	9.72E-02	1.03E-01	1.07E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-135: Hourly GWP Emissions from Microturbine in a Typical Day in January (ELF).

Option [kg]	CO2 Equivalent	CO2	CH4	N2O
Hour 3	1.27E+02	1.17E+02	4.56E-01	5.09E-04
Hour 4	1.26E+02	1.16E+02	4.54E-01	5.18E-04
hour 5	1.30E+02	1.20E+02	4.69E-01	5.52E-04
Hour 6	1.33E+02	1.23E+02	4.80E-01	5.81E-04
Hour 7	1.40E+02	1.29E+02	5.03E-01	5.67E-04
Hour 8	2.05E+02	1.89E+02	7.34E-01	6.32E-04
Hour 9	2.20E+02	2.03E+02	7.83E-01	4.39E-04
Hour 10	2.20E+02	2.03E+02	7.83E-01	4.39E-04
Hour 11	2.20E+02	2.03E+02	7.83E-01	4.39E-04
Hour 12	2.20E+02	2.03E+02	7.83E-01	4.39E-04
Hour 13	2.20E+02	2.03E+02	7.83E-01	4.39E-04
Hour 14	2.20E+02	2.03E+02	7.83E-01	4.39E-04
Hour 15	2.20E+02	2.03E+02	7.83E-01	4.39E-04
Hour 16	2.20E+02	2.03E+02	7.83E-01	4.39E-04
Hour 17	2.20E+02	2.03E+02	7.83E-01	4.39E-04
Hour 18	1.81E+02	1.67E+02	6.44E-01	3.60E-04
Hour 19	1.77E+02	1.64E+02	6.33E-01	5.07E-04
Hour 20	1.29E+02	1.19E+02	4.62E-01	4.22E-04
Hour 21	1.35E+02	1.24E+02	4.84E-01	4.88E-04
Hour 22	1.38E+02	1.27E+02	4.95E-01	5.39E-04

Table H-136: Hourly Primary Energy Consumption from Microturbine in a Typical Day in January (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	6.11E+02	6.10E+02	2.70E-01	2.07E-01
Hour 4	6.07E+02	6.07E+02	2.69E-01	2.06E-01
hour 5	6.28E+02	6.27E+02	2.78E-01	2.12E-01
Hour 6	6.42E+02	6.42E+02	2.84E-01	2.17E-01
Hour 7	6.74E+02	6.73E+02	2.98E-01	2.28E-01
Hour 8	9.84E+02	9.84E+02	4.35E-01	3.37E-01
Hour 9	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 10	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 11	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 12	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 13	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 14	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 15	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 16	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 17	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 18	8.63E+02	8.63E+02	3.82E-01	3.00E-01
Hour 19	8.49E+02	8.49E+02	3.76E-01	2.92E-01
Hour 20	6.19E+02	6.19E+02	2.74E-01	2.12E-01
Hour 21	6.48E+02	6.48E+02	2.87E-01	2.21E-01
Hour 22	6.64E+02	6.63E+02	2.93E-01	2.25E-01

Table H-137: Hourly Air Emissions from 3-MW ICE in a Typical Day in January (ELF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Benzene	1.28E-01	1.22E-01	1.19E-01	1.15E-01	1.39E-01	2.91E-01	4.16E-01	4.16E-01	4.16E-01	4.16E-01
Barium	2.31E-06	2.36E-06	2.53E-06	2.67E-06	2.58E-06	2.73E-06	8.58E-07	5.41E-07	5.02E-07	1.78E-07
arsenic	1.02E-07	1.05E-07	1.12E-07	1.18E-07	1.14E-07	1.21E-07	3.79E-08	2.39E-08	2.22E-08	7.86E-09
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehyde	0	0	0	0	0	0	0	0	0	0
NH3	2.50E-08	2.48E-08	2.56E-08	2.61E-08	2.75E-08	4.06E-08	3.88E-08	3.68E-08	3.65E-08	3.45E-08
H2S	5.80E-07	5.78E-07	5.97E-07	6.12E-07	6.41E-07	9.28E-07	8.60E-07	8.11E-07	8.05E-07	7.55E-07
NMVOC	1.14E-02	1.14E-02	1.18E-02	1.21E-02	1.26E-02	1.81E-02	1.65E-02	1.55E-02	1.54E-02	1.44E-02
CO	3.65E-01	3.51E-01	3.48E-01	3.40E-01	3.98E-01	7.71E-01	1.03E+00	1.03E+00	1.03E+00	1.02E+00
Particulates	8.68E-03	8.62E-03	8.87E-03	9.04E-03	9.58E-03	1.44E-02	1.41E-02	1.34E-02	1.34E-02	1.27E-02
HF	3.12E-05	3.11E-05	3.21E-05	3.29E-05	3.44E-05	4.99E-05	4.63E-05	4.36E-05	4.33E-05	4.06E-05
HCl	3.06E-04	3.05E-04	3.15E-04	3.23E-04	3.38E-04	4.90E-04	4.54E-04	4.28E-04	4.25E-04	3.99E-04
NOx	8.48E-02	8.36E-02	8.53E-02	8.61E-02	9.33E-02	1.49E-01	1.61E-01	1.56E-01	1.55E-01	1.50E-01
SO2	9.19E-03	9.15E-03	9.45E-03	9.68E-03	1.01E-02	1.47E-02	1.37E-02	1.29E-02	1.28E-02	1.21E-02
SO2 eq.	6.86E-02	6.76E-02	6.91E-02	7.00E-02	7.54E-02	1.19E-01	1.27E-01	1.22E-01	1.21E-01	1.17E-01
TOPP eq.	1.62E-01	1.59E-01	1.61E-01	1.62E-01	1.78E-01	2.96E-01	3.38E-01	3.29E-01	3.28E-01	3.19E-01

4.16E-01	4.16E-01	4.16E-01	4.16E-01	4.16E-01	3.42E-01	2.68E-01	1.72E-01	1.59E-01	1.45E-01	1.45E-01
0.00E+0 0	0.00E+0 0	0.00E+0 0	5.41E-08	4.33E-07	1.34E-06	2.16E-06	1.85E-06	2.18E-06	2.44E-06	2.44E-06
0.00E+0 0	0.00E+0 0	0.00E+0 0	2.39E-09	1.91E-08	5.95E-08	9.57E-08	8.17E-08	9.64E-08	1.08E-07	1.08E-07
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
3.35E-08	3.35E-08	3.35E-08	3.38E-08	3.61E-08	3.59E-08	3.52E-08	2.55E-08	2.66E-08	2.72E-08	2.72E-08
7.28E-07	7.28E-07	7.28E-07	7.36E-07	7.94E-07	8.05E-07	8.01E-07	5.84E-07	6.14E-07	6.30E-07	6.30E-07
1.39E-02	1.39E-02	1.39E-02	1.40E-02	1.52E-02	1.55E-02	1.56E-02	1.14E-02	1.20E-02	1.24E-02	1.24E-02
1.01E+0 0	1.01E+0 0	1.01E+0 0	1.02E+0 0	1.02E+0 0	8.64E-01	7.01E-01	4.60E-01	4.38E-01	4.10E-01	4.10E-01
1.23E-02	1.23E-02	1.23E-02	1.24E-02	1.32E-02	1.29E-02	1.25E-02	8.98E-03	9.32E-03	9.46E-03	9.46E-03
3.91E-05	3.91E-05	3.91E-05	3.95E-05	4.27E-05	4.33E-05	4.31E-05	3.14E-05	3.30E-05	3.39E-05	3.39E-05
3.84E-04	3.84E-04	3.84E-04	3.88E-04	4.20E-04	4.25E-04	4.23E-04	3.09E-04	3.24E-04	3.33E-04	3.33E-04
1.47E-01	1.47E-01	1.47E-01	1.48E-01	1.54E-01	1.44E-01	1.31E-01	9.21E-02	9.35E-02	9.31E-02	9.31E-02
1.16E-02	1.16E-02	1.16E-02	1.17E-02	1.27E-02	1.28E-02	1.27E-02	9.27E-03	9.73E-03	9.98E-03	9.98E-03
1.14E-01	1.14E-01	1.14E-01	1.15E-01	1.20E-01	1.13E-01	1.05E-01	7.38E-02	7.52E-02	7.51E-02	7.51E-02
3.14E-01	3.14E-01	3.14E-01	3.15E-01	3.26E-01	2.95E-01	2.63E-01	1.81E-01	1.81E-01	1.78E-01	1.78E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22	Hour 22

Table H-138: Hourly GWP Emissions from 3-MW ICE in a Typical Day in January (ELF).

Option [kg]	CO2 Equivalent	CO2	CH4	N2O
Hour 3	1.19E+02	1.08E+02	4.80E-01	1.78E-03
Hour 4	1.18E+02	1.08E+02	4.77E-01	1.73E-03
hour 5	1.23E+02	1.12E+02	4.91E-01	1.74E-03
Hour 6	1.26E+02	1.15E+02	5.01E-01	1.72E-03
Hour 7	1.31E+02	1.20E+02	5.30E-01	1.95E-03
Hour 8	1.87E+02	1.69E+02	7.88E-01	3.52E-03
Hour 9	1.67E+02	1.50E+02	7.64E-01	4.40E-03
Hour 10	1.57E+02	1.40E+02	7.26E-01	4.34E-03
Hour 11	1.55E+02	1.39E+02	7.21E-01	4.33E-03
Hour 12	1.45E+02	1.29E+02	6.83E-01	4.26E-03
Hour 13	1.39E+02	1.24E+02	6.61E-01	4.22E-03
Hour 14	1.39E+02	1.24E+02	6.61E-01	4.22E-03
Hour 15	1.39E+02	1.24E+02	6.61E-01	4.22E-03
Hour 16	1.41E+02	1.25E+02	6.67E-01	4.24E-03
Hour 17	1.53E+02	1.37E+02	7.13E-01	4.32E-03
Hour 18	1.58E+02	1.42E+02	7.04E-01	3.75E-03
Hour 19	1.60E+02	1.45E+02	6.84E-01	3.17E-03
Hour 20	1.18E+02	1.07E+02	4.94E-01	2.13E-03
Hour 21	1.25E+02	1.13E+02	5.14E-01	2.07E-03
Hour 22	1.29E+02	1.17E+02	5.23E-01	1.98E-03

Table H-139: Hourly Primary Energy Consumption from 3-MW ICE in a Typical Day in January (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	6.02E+02	6.01E+02	2.66E-01	2.12E-01
Hour 4	5.99E+02	5.99E+02	2.65E-01	2.11E-01
hour 5	6.19E+02	6.19E+02	2.74E-01	2.17E-01
Hour 6	6.34E+02	6.34E+02	2.81E-01	2.22E-01
Hour 7	6.65E+02	6.64E+02	2.94E-01	2.34E-01
Hour 8	9.63E+02	9.62E+02	4.27E-01	3.50E-01
Hour 9	8.92E+02	8.92E+02	3.96E-01	3.40E-01
Hour 10	8.42E+02	8.41E+02	3.74E-01	3.23E-01
Hour 11	8.36E+02	8.35E+02	3.71E-01	3.21E-01
Hour 12	7.84E+02	7.83E+02	3.48E-01	3.04E-01
Hour 13	7.55E+02	7.54E+02	3.35E-01	2.95E-01
Hour 14	7.55E+02	7.54E+02	3.35E-01	2.95E-01
Hour 15	7.55E+02	7.54E+02	3.35E-01	2.95E-01
Hour 16	7.63E+02	7.62E+02	3.39E-01	2.97E-01
Hour 17	8.25E+02	8.24E+02	3.66E-01	3.17E-01
Hour 18	8.35E+02	8.35E+02	3.70E-01	3.13E-01
Hour 19	8.31E+02	8.30E+02	3.68E-01	3.03E-01
Hour 20	6.06E+02	6.06E+02	2.69E-01	2.19E-01
Hour 21	6.37E+02	6.36E+02	2.82E-01	2.27E-01
Hour 22	6.54E+02	6.53E+02	2.89E-01	2.31E-01

Table H-140: Hourly Air Emissions from 143-kW ICE in a Typical Day in January (ELF).

Benzene	1.28E-01	1.22E-01	1.19E-01	1.15E-01	1.39E-01	2.91E-01	4.16E-01	4.16E-01	4.16E-01	4.16E-01
Barium	1.88E-06	1.95E-06	2.13E-06	2.29E-06	2.11E-06	1.74E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
arsenic	8.31E-08	8.62E-08	9.40E-08	1.01E-07	9.33E-08	7.69E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehyde	0	0	0	0	0	0	0	0	0	0
NH3	2.47E-08	2.46E-08	2.54E-08	2.59E-08	2.73E-08	3.99E-08	4.16E-08	4.16E-08	4.16E-08	4.16E-08
H2S	5.88E-07	5.84E-07	6.04E-07	6.18E-07	6.49E-07	9.45E-07	9.69E-07	9.69E-07	9.69E-07	9.69E-07
NMVOC	1.15E-02	1.14E-02	1.19E-02	1.22E-02	1.27E-02	1.83E-02	1.84E-02	1.84E-02	1.84E-02	1.84E-02
CO	4.59E-01	4.40E-01	4.34E-01	4.23E-01	4.99E-01	9.82E-01	1.35E+00	1.35E+00	1.35E+00	1.35E+00
Particulates	9.00E-03	8.90E-03	9.16E-03	9.32E-03	9.91E-03	1.51E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02
HF	3.16E-05	3.14E-05	3.25E-05	3.33E-05	3.49E-05	5.08E-05	5.21E-05	5.21E-05	5.21E-05	5.21E-05
HCl	3.10E-04	3.08E-04	3.19E-04	3.26E-04	3.42E-04	4.99E-04	5.11E-04	5.11E-04	5.11E-04	5.11E-04
NOx	9.23E-02	9.06E-02	9.22E-02	9.28E-02	1.01E-01	1.66E-01	1.95E-01	1.95E-01	1.95E-01	1.95E-01
SO2	9.29E-03	9.23E-03	9.54E-03	9.77E-03	1.02E-02	1.49E-02	1.53E-02	1.53E-02	1.53E-02	1.53E-02
SO2 Equivalent	7.39E-02	7.27E-02	7.41E-02	7.47E-02	8.12E-02	1.31E-01	1.52E-01	1.52E-01	1.52E-01	1.52E-01
TOPP eq.	1.82E-01	1.77E-01	1.79E-01	1.79E-01	1.99E-01	3.40E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

4.16E-01	4.16E-01	4.16E-01	4.16E-01	4.16E-01	3.42E-01	2.68E-01	1.72E-01	1.59E-01	1.45E-01
0.00E+00	0	0	0.00E+00	0.00E+00	1.85E-07	1.25E-06	1.27E-06	1.64E-06	1.95E-06
0.00E+00	0	0	0.00E+00	0.00E+00	8.21E-09	5.54E-08	5.61E-08	7.25E-08	8.62E-08
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4.16E-08	4.16E-08	4.16E-08	4.16E-08	4.16E-08	3.53E-08	3.46E-08	2.52E-08	2.63E-08	2.69E-08
9.69E-07	9.69E-07	9.69E-07	9.69E-07	9.69E-07	8.24E-07	8.16E-07	5.95E-07	6.23E-07	6.38E-07
1.84E-02	1.84E-02	1.84E-02	1.84E-02	1.84E-02	1.57E-02	1.57E-02	1.15E-02	1.21E-02	1.25E-02
1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.11E+00	8.96E-01	5.85E-01	5.53E-01	5.15E-01
1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.38E-02	1.31E-02	9.40E-03	9.70E-03	9.81E-03
5.21E-05	5.21E-05	5.21E-05	5.21E-05	5.21E-05	4.44E-05	4.39E-05	3.20E-05	3.35E-05	3.43E-05
5.11E-04	5.11E-04	5.11E-04	5.11E-04	5.11E-04	4.35E-04	4.31E-04	3.14E-04	3.29E-04	3.37E-04
1.95E-01	1.95E-01	1.95E-01	1.95E-01	1.95E-01	1.63E-01	1.47E-01	1.02E-01	1.03E-01	1.02E-01
1.53E-02	1.53E-02	1.53E-02	1.53E-02	1.53E-02	1.31E-02	1.29E-02	9.41E-03	9.85E-03	1.01E-02
1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.27E-01	1.16E-01	8.09E-02	8.17E-02	8.11E-02
4.17E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01	3.48E-01	3.03E-01	2.08E-01	2.06E-01	2.01E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-141: Hourly GWP Emissions from 143-kW ICE in a Typical Day in January (ELF).

Option [kg]	CO2 Equivalent	CO2	CH4	N2O
Hour 3	1.19E+02	1.08E+02	4.96E-01	2.13E-03
Hour 4	1.18E+02	1.07E+02	4.91E-01	2.06E-03
hour 5	1.23E+02	1.11E+02	5.06E-01	2.05E-03
Hour 6	1.26E+02	1.15E+02	5.15E-01	2.02E-03
Hour 7	1.31E+02	1.19E+02	5.46E-01	2.32E-03
Hour 8	1.86E+02	1.68E+02	8.23E-01	4.29E-03
Hour 9	1.85E+02	1.65E+02	8.80E-01	5.62E-03
Hour 10	1.85E+02	1.65E+02	8.80E-01	5.62E-03
Hour 11	1.85E+02	1.65E+02	8.80E-01	5.62E-03
Hour 12	1.85E+02	1.65E+02	8.80E-01	5.62E-03
Hour 13	1.85E+02	1.65E+02	8.80E-01	5.62E-03
Hour 14	1.85E+02	1.65E+02	8.80E-01	5.62E-03
Hour 15	1.85E+02	1.65E+02	8.80E-01	5.62E-03
Hour 16	1.85E+02	1.65E+02	8.80E-01	5.62E-03
Hour 17	1.85E+02	1.65E+02	8.80E-01	5.62E-03
Hour 18	1.58E+02	1.41E+02	7.45E-01	4.66E-03
Hour 19	1.60E+02	1.44E+02	7.16E-01	3.88E-03
Hour 20	1.18E+02	1.06E+02	5.15E-01	2.58E-03
Hour 21	1.25E+02	1.13E+02	5.33E-01	2.49E-03
Hour 22	1.29E+02	1.16E+02	5.40E-01	2.37E-03

Table H-142: Hourly Primary Energy Consumption from 143-kW ICE in a Typical Day in January (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	6.10E+02	6.09E+02	2.70E-01	2.08E-01
Hour 4	6.06E+02	6.05E+02	2.68E-01	2.07E-01
hour 5	6.27E+02	6.26E+02	2.77E-01	2.13E-01
Hour 6	6.41E+02	6.41E+02	2.84E-01	2.18E-01
Hour 7	6.73E+02	6.72E+02	2.98E-01	2.30E-01
Hour 8	9.80E+02	9.79E+02	4.34E-01	3.39E-01
Hour 9	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 10	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 11	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 12	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 13	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 14	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 15	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 16	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 17	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 18	8.56E+02	8.55E+02	3.79E-01	3.01E-01
Hour 19	8.46E+02	8.46E+02	3.75E-01	2.94E-01
Hour 20	6.17E+02	6.17E+02	2.73E-01	2.13E-01
Hour 21	6.46E+02	6.46E+02	2.86E-01	2.22E-01
Hour 22	6.62E+02	6.61E+02	2.93E-01	2.26E-01

Table H-143: Hourly Air Emissions from SOFC in a Typical Day in January (ELF).

Benzene	0	0	0	0	0	0	0	0	0	0
Barium	0	0	0	0	0	0	0	0	0	0
arsenic	0	0	0	0	0	0	0	0	0	0
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehyde	0	0	0	0	0	0	0	0	0	0
NH3	6.41E-09	6.02E-09	5.74E-09	5.45E-09	6.88E-09	2.11E-08	3.19E-08	3.26E-08	3.44E-08	3.56E-08
H2S	1.50E-07	1.41E-07	1.35E-07	1.28E-07	1.62E-07	4.84E-07	7.23E-07	7.37E-07	7.72E-07	7.94E-07
NMVOC	5.40E-04	5.08E-04	4.84E-04	4.60E-04	5.81E-04	1.74E-03	2.60E-03	2.65E-03	2.78E-03	2.86E-03
CO	4.64E-03	4.36E-03	4.15E-03	3.95E-03	4.99E-03	1.51E-02	2.26E-02	2.30E-02	2.42E-02	2.49E-02
Particulates	4.77E-04	4.49E-04	4.27E-04	4.06E-04	5.13E-04	1.54E-03	2.31E-03	2.36E-03	2.48E-03	2.55E-03
HF	9.35E-06	8.79E-06	8.37E-06	7.95E-06	1.00E-05	3.01E-05	4.50E-05	4.58E-05	4.81E-05	4.94E-05
HCl	8.17E-05	7.68E-05	7.31E-05	6.95E-05	8.78E-05	2.63E-04	3.93E-04	4.01E-04	4.20E-04	4.32E-04
NOx	5.98E-03	5.62E-03	5.35E-03	5.09E-03	6.42E-03	1.93E-02	2.88E-02	2.93E-02	3.08E-02	3.16E-02
SO2	2.33E-03	2.19E-03	2.09E-03	1.99E-03	2.51E-03	7.53E-03	1.13E-02	1.15E-02	1.20E-02	1.24E-02
SO2 eq.	6.58E-03	6.19E-03	5.89E-03	5.60E-03	7.07E-03	2.12E-02	3.17E-02	3.23E-02	3.39E-02	3.49E-02
TOPP eq.	9.97E-03	9.38E-03	8.93E-03	8.48E-03	1.07E-02	3.21E-02	4.81E-02	4.89E-02	5.13E-02	5.28E-02
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
3.51E-08	3.49E-08	3.46E-08	3.64E-08	3.71E-08	3.19E-08	2.51E-08	1.58E-08	1.11E-08	8.37E-09
7.85E-07	7.81E-07	7.76E-07	8.09E-07	8.24E-07	7.04E-07	5.53E-07	3.47E-07	2.50E-07	1.93E-07
2.82E-03	2.81E-03	2.79E-03	2.91E-03	2.96E-03	2.53E-03	1.99E-03	1.25E-03	8.99E-04	6.93E-04
2.46E-02	2.45E-02	2.43E-02	2.54E-02	2.59E-02	2.22E-02	1.74E-02	1.09E-02	7.81E-03	5.99E-03
2.52E-03	2.50E-03	2.49E-03	2.60E-03	2.65E-03	2.26E-03	1.78E-03	1.12E-03	8.00E-04	6.14E-04
4.89E-05	4.86E-05	4.83E-05	5.04E-05	5.13E-05	4.38E-05	3.44E-05	2.16E-05	1.56E-05	1.20E-05
4.27E-04	4.25E-04	4.22E-04	4.40E-04	4.48E-04	3.83E-04	3.01E-04	1.89E-04	1.36E-04	1.05E-04
3.13E-02	3.11E-02	3.09E-02	3.23E-02	3.28E-02	2.80E-02	2.21E-02	1.38E-02	9.96E-03	7.67E-03
1.22E-02	1.22E-02	1.21E-02	1.26E-02	1.28E-02	1.10E-02	8.63E-03	5.42E-03	3.90E-03	3.00E-03
3.45E-02	3.43E-02	3.41E-02	3.55E-02	3.62E-02	3.09E-02	2.43E-02	1.53E-02	1.10E-02	8.45E-03
5.22E-02	5.19E-02	5.16E-02	5.38E-02	5.48E-02	4.68E-02	3.68E-02	2.31E-02	1.66E-02	1.28E-02
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-144: Hourly GWP Emissions from SOFC in a Typical Day in January (ELF).

Option [kg]	CO2 Equivalent	CO2	CH4	N2O
Hour 3	3.199998286E+01	2.95E+01	1.16E-01	6.56E-05
Hour 4	3.01E+01	2.78E+01	1.09E-01	6.17E-05
hour 5	2.87E+01	2.64E+01	1.04E-01	5.88E-05
Hour 6	2.72E+01	2.51E+01	9.90E-02	5.58E-05
Hour 7	3.44E+01	3.17E+01	1.25E-01	7.05E-05
Hour 8	1.03E+02	9.50E+01	3.74E-01	2.11E-04
Hour 9	1.54E+02	1.42E+02	5.60E-01	3.16E-04
Hour 10	1.57E+02	1.45E+02	5.70E-01	3.22E-04
Hour 11	1.64E+02	1.52E+02	5.98E-01	3.37E-04
Hour 12	1.69E+02	1.56E+02	6.15E-01	3.47E-04
Hour 13	1.67E+02	1.54E+02	6.08E-01	3.43E-04
Hour 14	1.66E+02	1.53E+02	6.04E-01	3.41E-04
Hour 15	1.65E+02	1.52E+02	6.01E-01	3.39E-04
Hour 16	1.72E+02	1.59E+02	6.26E-01	3.54E-04
Hour 17	1.75E+02	1.62E+02	6.37E-01	3.60E-04
Hour 18	1.50E+02	1.38E+02	5.45E-01	3.07E-04
Hour 19	1.18E+02	1.09E+02	4.28E-01	2.42E-04
Hour 20	7.39E+01	6.82E+01	2.69E-01	1.52E-04
Hour 21	5.32E+01	4.91E+01	1.94E-01	1.09E-04
Hour 22	4.10E+01	3.78E+01	1.49E-01	8.42E-05

Table H-145: Hourly Primary Energy Consumption from SOFC in a Typical Day in January (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	1.56E+02	1.56E+02	7.54E-02	5.53E-02
Hour 4	1.47E+02	1.47E+02	7.09E-02	5.20E-02
hour 5	1.40E+02	1.40E+02	6.76E-02	4.95E-02
Hour 6	1.33E+02	1.33E+02	6.42E-02	4.70E-02
Hour 7	1.68E+02	1.67E+02	8.11E-02	5.94E-02
Hour 8	5.02E+02	5.02E+02	2.43E-01	1.82E-01
Hour 9	7.51E+02	7.50E+02	3.63E-01	2.74E-01
Hour 10	7.65E+02	7.64E+02	3.70E-01	2.79E-01
Hour 11	8.02E+02	8.01E+02	3.88E-01	2.95E-01
Hour 12	8.25E+02	8.24E+02	3.99E-01	3.04E-01
Hour 13	8.15E+02	8.14E+02	3.95E-01	3.00E-01
Hour 14	8.11E+02	8.10E+02	3.93E-01	2.98E-01
Hour 15	8.06E+02	8.05E+02	3.90E-01	2.96E-01
Hour 16	8.40E+02	8.40E+02	4.07E-01	3.11E-01
Hour 17	8.55E+02	8.54E+02	4.14E-01	3.17E-01
Hour 18	7.30E+02	7.30E+02	3.54E-01	2.72E-01
Hour 19	5.74E+02	5.74E+02	2.78E-01	2.14E-01
Hour 20	3.60E+02	3.60E+02	1.75E-01	1.34E-01
Hour 21	2.60E+02	2.59E+02	1.26E-01	9.47E-02
Hour 22	2.00E+02	2.00E+02	9.68E-02	7.20E-02

Table H-146: Hourly Air Emissions from Microturbine in a Typical Day in January (ELF).

Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Zinc	1.15E-05	1.20E-05	1.31E-05	1.42E-05	1.29E-05	1.00E-05	0.00E+0	0	0	0
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	2.18E-03	2.28E-03	2.49E-03	2.69E-03	2.45E-03	1.90E-03	0.00E+0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
Vanadium	9.19E-07	9.59E-07	1.05E-06	1.13E-06	1.03E-06	8.00E-07	0.00E+0	0	0	0
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	4.37E-03	4.56E-03	4.99E-03	5.39E-03	4.92E-03	3.80E-03	0.00E+0	0	0	0
Selenium	9.51E-09	9.92E-09	1.09E-08	1.17E-08	1.07E-08	8.28E-09	0.00E+0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	8.33E-07	8.69E-07	9.52E-07	1.03E-06	9.38E-07	7.26E-07	0.00E+0	0	0	0
Molybdenu	4.37E-07	4.56E-07	4.99E-07	5.39E-07	4.92E-07	3.80E-07	0.00E+0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	1.03E-07	1.08E-07	1.18E-07	1.27E-07	1.16E-07	8.99E-08	0.00E+0	0	0	0
Manganese	1.51E-07	1.57E-07	1.72E-07	1.86E-07	1.70E-07	1.31E-07	0.00E+0	0	0	0
Lead	1.98E-07	2.07E-07	2.26E-07	2.44E-07	2.23E-07	1.73E-07	0.00E+0	0	0	0
HC	6.44E-03	6.13E-03	5.97E-03	5.74E-03	6.98E-03	1.46E-02	2.09E-02	2.09E-02	2.09E-02	2.09E-02
Copper	3.37E-07	3.52E-07	3.85E-07	4.16E-07	3.79E-07	2.93E-07	0.00E+0	0	0	0
Cobalt	3.33E-08	3.48E-08	3.81E-08	4.11E-08	3.75E-08	2.90E-08	0.00E+0	0	0	0
Chromium	5.54E-07	5.78E-07	6.33E-07	6.83E-07	6.24E-07	4.83E-07	0.00E+0	0	0	0
Cadmium	4.37E-07	4.56E-07	4.99E-07	5.39E-07	4.92E-07	3.80E-07	0.00E+0	0	0	0
Beryllium	4.77E-09	4.98E-09	5.45E-09	5.89E-09	5.37E-09	4.16E-09	0.00E+0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0
Barium	1.79E-06	1.87E-06	2.05E-06	2.21E-06	2.02E-06	1.56E-06	0.00E+0	0	0	0
arsenic	7.93E-08	8.27E-08	9.06E-08	9.78E-08	8.92E-08	6.91E-08	0.00E+0	0	0	0
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehy	0	0	0	0	0	0	0	0	0	0
NH3	2.47E-08	2.45E-08	2.53E-08	2.59E-08	2.72E-08	3.99E-08	4.31E-08	4.31E-08	4.31E-08	4.31E-08
H2S	5.89E-07	5.85E-07	6.05E-07	6.19E-07	6.49E-07	9.49E-07	1.01E-06	1.01E-06	1.01E-06	1.01E-06
NMVOC	6.46E-03	6.66E-03	7.18E-03	7.65E-03	7.23E-03	6.90E-03	2.96E-03	2.96E-03	2.96E-03	2.96E-03
CO	9.92E-02	9.81E-02	1.01E-01	1.02E-01	1.09E-01	1.68E-01	1.90E-01	1.90E-01	1.90E-01	1.90E-01
Particulates	4.69E-03	4.81E-03	5.16E-03	5.48E-03	5.24E-03	5.33E-03	2.90E-03	2.90E-03	2.90E-03	2.90E-03
HF	3.17E-05	3.15E-05	3.25E-05	3.33E-05	3.49E-05	5.10E-05	5.45E-05	5.45E-05	5.45E-05	5.45E-05
HCl	3.11E-04	3.09E-04	3.19E-04	3.27E-04	3.43E-04	5.01E-04	5.35E-04	5.35E-04	5.35E-04	5.35E-04
NOx	6.15E-02	6.13E-02	6.36E-02	6.53E-02	6.79E-02	9.65E-02	9.97E-02	9.97E-02	9.97E-02	9.97E-02
SO2	9.48E-03	9.42E-03	9.73E-03	9.94E-03	1.05E-02	1.54E-02	1.66E-02	1.66E-02	1.66E-02	1.66E-02
SO2 eq.	5.26E-02	5.24E-02	5.44E-02	5.57E-02	5.81E-02	8.31E-02	8.66E-02	8.66E-02	8.66E-02	8.66E-02
TOPP eq.	9.88E-02	9.86E-02	1.02E-01	1.05E-01	1.09E-01	1.53E-01	1.56E-01	1.56E-01	1.56E-01	1.56E-01

0	0	0	0	0	0.00E+0	6.93E-06	7.43E-06	9.86E-06	1.19E-05
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	1.32E-03	1.41E-03	1.87E-03	2.26E-03
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	5.55E-07	5.94E-07	7.88E-07	9.51E-07
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	2.64E-03	2.83E-03	3.75E-03	4.52E-03
0	0	0	0	0	0.00E+0	5.74E-09	6.15E-09	8.16E-09	9.84E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	5.03E-07	5.39E-07	7.15E-07	8.62E-07
0	0	0	0	0	0.00E+0	2.64E-07	2.83E-07	3.75E-07	4.52E-07
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	6.23E-08	6.68E-08	8.86E-08	1.07E-07
0	0	0	0	0	0.00E+0	9.11E-08	9.76E-08	1.29E-07	1.56E-07
0	0	0	0	0	0.00E+0	1.20E-07	1.28E-07	1.70E-07	2.05E-07
2.09E-02	2.09E-02	2.09E-02	2.09E-02	2.09E-02	1.71E-02	1.34E-02	8.61E-03	7.99E-03	7.29E-03
0	0	0	0	0	0.00E+0	2.03E-07	2.18E-07	2.89E-07	3.49E-07
0	0	0	0	0	0.00E+0	2.01E-08	2.16E-08	2.86E-08	3.45E-08
0	0	0	0	0	0.00E+0	3.35E-07	3.58E-07	4.76E-07	5.74E-07
0	0	0	0	0	0.00E+0	2.64E-07	2.83E-07	3.75E-07	4.52E-07
0	0	0	0	0	0.00E+0	2.88E-09	3.09E-09	4.10E-09	4.94E-09
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.00E+0	1.08E-06	1.16E-06	1.54E-06	1.85E-06
0	0	0	0	0	0.00E+0	4.79E-08	5.13E-08	6.80E-08	8.21E-08
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4.31E-08	4.31E-08	4.31E-08	4.31E-08	4.31E-08	3.54E-08	3.45E-08	2.51E-08	2.62E-08	2.68E-08
1.01E-06	1.01E-06	1.01E-06	1.01E-06	1.01E-06	8.33E-07	8.18E-07	5.97E-07	6.25E-07	6.40E-07
2.96E-03	2.96E-03	2.96E-03	2.96E-03	2.96E-03	2.43E-03	5.25E-03	4.81E-03	5.89E-03	6.77E-03
1.90E-01	1.90E-01	1.90E-01	1.90E-01	1.90E-01	1.56E-01	1.46E-01	1.05E-01	1.07E-01	1.08E-01
2.90E-03	2.90E-03	2.90E-03	2.90E-03	2.90E-03	2.38E-03	4.16E-03	3.65E-03	4.37E-03	4.94E-03
5.45E-05	5.45E-05	5.45E-05	5.45E-05	5.45E-05	4.47E-05	4.40E-05	3.21E-05	3.36E-05	3.44E-05
5.35E-04	5.35E-04	5.35E-04	5.35E-04	5.35E-04	4.39E-04	4.32E-04	3.15E-04	3.30E-04	3.38E-04
9.97E-02	9.97E-02	9.97E-02	9.97E-02	9.97E-02	8.19E-02	8.27E-02	6.10E-02	6.45E-02	6.66E-02
1.66E-02	1.66E-02	1.66E-02	1.66E-02	1.66E-02	1.37E-02	1.33E-02	9.68E-03	1.01E-02	1.03E-02
8.66E-02	8.66E-02	8.66E-02	8.66E-02	8.66E-02	7.12E-02	7.13E-02	5.25E-02	5.54E-02	5.71E-02
1.56E-01	1.56E-01	1.56E-01	1.56E-01	1.56E-01	1.29E-01	1.31E-01	9.72E-02	1.03E-01	1.07E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-147: Hourly GWP Emissions from Microturbine in a Typical Day in January (ELF).

Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
CO2 eq.	1.27E+0	1.26E+0	1.30E+0	1.33E+0	1.40E+0	2.05E+0	2.20E+0	2.20E+0	2.20E+0
CO2	1.17E+0	1.16E+0	1.20E+0	1.23E+0	1.29E+0	1.89E+0	2.03E+0	2.03E+0	2.03E+0
CH4	4.56E-01	4.54E-01	4.69E-01	4.80E-01	5.03E-01	7.34E-01	7.83E-01	7.83E-01	7.83E-01
N2O	5.09E-04	5.18E-04	5.52E-04	5.81E-04	5.67E-04	6.32E-04	4.39E-04	4.39E-04	4.39E-04
HFC-23	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0
HFC-43-	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0
SF6	0	0	0	0	0	0	0	0	0
Perfluorometh	3.89E-09	3.87E-09	4.00E-09	4.08E-09	4.29E-09	6.30E-09	6.79E-09	6.79E-09	6.79E-09
Perfluoroetha	4.89E-10	4.86E-10	5.02E-10	5.13E-10	5.40E-10	7.92E-10	8.54E-10	8.54E-10	8.54E-10
Perfluorocycl	0	0	0	0	0	0	0	0	0
Perfluorohexa	0	0	0	0	0	0	0	0	0
Perfluoroprop	0	0	0	0	0	0	0	0	0
Perfluorobuta	0	0	0	0	0	0	0	0	0
Perfluoropent	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
8.54E-10	8.54E-10	8.54E-10	8.54E-10	8.54E-10	8.54E-10	7.01E-10	6.85E-10	4.98E-10	5.20E-10	5.32E-10
6.79E-09	6.79E-09	6.79E-09	6.79E-09	6.79E-09	6.79E-09	5.58E-09	5.45E-09	3.96E-09	4.14E-09	4.23E-09
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
4.39E-04	4.39E-04	4.39E-04	4.39E-04	4.39E-04	4.39E-04	3.60E-04	5.07E-04	4.22E-04	4.88E-04	5.39E-04
7.83E-01	7.83E-01	7.83E-01	7.83E-01	7.83E-01	7.83E-01	6.44E-01	6.33E-01	4.62E-01	4.84E-01	4.95E-01
2.03E+0	2.03E+0	2.03E+0	2.03E+0	2.03E+0	2.03E+0	1.67E+0	1.64E+0	1.19E+0	1.24E+0	1.27E+0
2.20E+0	2.20E+0	2.20E+0	2.20E+0	2.20E+0	2.20E+0	1.81E+0	1.77E+0	1.29E+0	1.35E+0	1.38E+0
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-148: Hourly Primary Energy Consumption from Microturbine in a Typical Day in January (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	6.11E+02	6.10E+02	2.70E-01	2.07E-01
Hour 4	6.07E+02	6.07E+02	2.69E-01	2.06E-01
hour 5	6.28E+02	6.27E+02	2.78E-01	2.12E-01
Hour 6	6.42E+02	6.42E+02	2.84E-01	2.17E-01
Hour 7	6.74E+02	6.73E+02	2.98E-01	2.28E-01
Hour 8	9.84E+02	9.84E+02	4.35E-01	3.37E-01
Hour 9	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 10	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 11	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 12	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 13	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 14	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 15	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 16	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 17	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 18	8.63E+02	8.63E+02	3.82E-01	3.00E-01
Hour 19	8.49E+02	8.49E+02	3.76E-01	2.92E-01
Hour 20	6.19E+02	6.19E+02	2.74E-01	2.12E-01
Hour 21	6.48E+02	6.48E+02	2.87E-01	2.21E-01
Hour 22	6.64E+02	6.63E+02	2.93E-01	2.25E-01

Table H-149: Hourly Air Emissions from 3-MW ICE in a Typical Day in January (ELF).

Zinc	1.48E-05	1.52E-05	1.62E-05	1.71E-05	1.65E-05	1.75E-05	5.50E-06	3.47E-06	3.22E-06	1.14E-06
Xylene	6.42E-05	6.11E-05	5.96E-05	5.73E-05	6.96E-05	1.45E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04
VOC	2.81E-03	2.88E-03	3.07E-03	3.25E-03	3.14E-03	3.32E-03	1.04E-03	6.58E-04	6.11E-04	2.16E-04
VOC	0	0	0	0	0	0	0	0	0	0
Vanadium	1.18E-06	1.21E-06	1.30E-06	1.37E-06	1.32E-06	1.40E-06	4.40E-07	2.77E-07	2.58E-07	9.11E-08
Toluene	1.84E-04	1.75E-04	1.70E-04	1.64E-04	1.99E-04	4.16E-04	5.95E-04	5.95E-04	5.95E-04	5.95E-04
TOC	6.15E-03	6.26E-03	6.64E-03	6.98E-03	6.86E-03	7.83E-03	3.78E-03	3.01E-03	2.91E-03	2.12E-03
Selenium	1.23E-08	1.25E-08	1.34E-08	1.42E-08	1.37E-08	1.45E-08	4.55E-09	2.87E-09	2.66E-09	9.43E-10
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	1.07E-06	1.10E-06	1.17E-06	1.24E-06	1.20E-06	1.27E-06	3.99E-07	2.51E-07	2.33E-07	8.26E-08
Molybdenu	5.63E-07	5.76E-07	6.16E-07	6.52E-07	6.29E-07	6.65E-07	2.09E-07	1.32E-07	1.22E-07	4.33E-08
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	1.33E-07	1.36E-07	1.46E-07	1.54E-07	1.49E-07	1.57E-07	4.94E-08	3.12E-08	2.89E-08	1.02E-08
Manganese	1.94E-07	1.99E-07	2.13E-07	2.25E-07	2.17E-07	2.30E-07	7.22E-08	4.55E-08	4.23E-08	1.50E-08
Lead	2.56E-07	2.62E-07	2.79E-07	2.96E-07	2.85E-07	3.02E-07	9.49E-08	5.98E-08	5.56E-08	1.97E-08
HC	0	0	0	0	0	0	0	0	0	0
Copper	4.34E-07	4.45E-07	4.75E-07	5.03E-07	4.85E-07	5.13E-07	1.61E-07	1.02E-07	9.44E-08	3.34E-08
Cobalt	4.30E-08	4.40E-08	4.70E-08	4.97E-08	4.80E-08	5.07E-08	1.60E-08	1.01E-08	9.34E-09	3.31E-09
Chromium	7.14E-07	7.31E-07	7.81E-07	8.27E-07	7.98E-07	8.44E-07	2.65E-07	1.67E-07	1.55E-07	5.50E-08
Cadmium	5.63E-07	5.76E-07	6.16E-07	6.52E-07	6.29E-07	6.65E-07	2.09E-07	1.32E-07	1.22E-07	4.33E-08
Beryllium	6.15E-09	6.30E-09	6.73E-09	7.12E-09	6.87E-09	7.26E-09	2.28E-09	1.44E-09	1.34E-09	4.73E-10
Benzene	1.28E-01	1.22E-01	1.19E-01	1.15E-01	1.39E-01	2.91E-01	4.16E-01	4.16E-01	4.16E-01	4.16E-01
Barium	2.31E-06	2.36E-06	2.53E-06	2.67E-06	2.58E-06	2.73E-06	8.58E-07	5.41E-07	5.02E-07	1.78E-07
arsenic	1.02E-07	1.05E-07	1.12E-07	1.18E-07	1.14E-07	1.21E-07	3.79E-08	2.39E-08	2.22E-08	7.86E-09
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehy	0	0	0	0	0	0	0	0	0	0
NH3	2.50E-08	2.48E-08	2.56E-08	2.61E-08	2.75E-08	4.06E-08	3.88E-08	3.68E-08	3.65E-08	3.45E-08
H2S	5.80E-07	5.78E-07	5.97E-07	6.12E-07	6.41E-07	9.28E-07	8.60E-07	8.11E-07	8.05E-07	7.55E-07
NMVOC	1.14E-02	1.14E-02	1.18E-02	1.21E-02	1.26E-02	1.81E-02	1.65E-02	1.55E-02	1.54E-02	1.44E-02
CO	3.65E-01	3.51E-01	3.48E-01	3.40E-01	3.98E-01	7.71E-01	1.03E+0	1.03E+0	1.03E+0	1.02E+0
Particulates	8.68E-03	8.62E-03	8.87E-03	9.04E-03	9.58E-03	1.44E-02	1.41E-02	1.34E-02	1.34E-02	1.27E-02
HF	3.12E-05	3.11E-05	3.21E-05	3.29E-05	3.44E-05	4.99E-05	4.63E-05	4.36E-05	4.33E-05	4.06E-05
HCl	3.06E-04	3.05E-04	3.15E-04	3.23E-04	3.38E-04	4.90E-04	4.54E-04	4.28E-04	4.25E-04	3.99E-04
NOx	8.48E-02	8.36E-02	8.53E-02	8.61E-02	9.33E-02	1.49E-01	1.61E-01	1.56E-01	1.55E-01	1.50E-01
SO2	9.19E-03	9.15E-03	9.45E-03	9.68E-03	1.01E-02	1.47E-02	1.37E-02	1.29E-02	1.28E-02	1.21E-02
SO2 eq.	6.86E-02	6.76E-02	6.91E-02	7.00E-02	7.54E-02	1.19E-01	1.27E-01	1.22E-01	1.21E-01	1.17E-01
TOPP eq.	1.62E-01	1.59E-01	1.61E-01	1.62E-01	1.78E-01	2.96E-01	3.38E-01	3.29E-01	3.28E-01	3.19E-01
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0.00E+0	0.00E+0	0.00E+0	3.47E-07	2.77E-06	8.62E-06	1.39E-05	1.18E-05	1.40E-05	1.57E-05	1.57E-05
2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	1.71E-04	1.34E-04	8.59E-05	7.97E-05	7.27E-05	7.27E-05
0.00E+0	0.00E+0	0.00E+0	6.58E-05	5.26E-04	1.64E-03	2.63E-03	2.25E-03	2.65E-03	2.97E-03	2.97E-03
0	0	0	0	0	0	0	0	0	0	0
0.00E+0	0.00E+0	0.00E+0	2.77E-08	2.22E-07	6.89E-07	1.11E-06	9.47E-07	1.12E-06	1.25E-06	1.25E-06
5.95E-04	5.95E-04	5.95E-04	5.95E-04	5.95E-04	4.89E-04	3.83E-04	2.46E-04	2.28E-04	2.08E-04	2.08E-04
1.69E-03	1.69E-03	1.69E-03	1.82E-03	2.74E-03	4.66E-03	6.36E-03	5.20E-03	5.96E-03	6.54E-03	6.54E-03
0.00E+0	0.00E+0	0.00E+0	2.87E-10	2.30E-09	7.13E-09	1.15E-08	9.79E-09	1.16E-08	1.30E-08	1.30E-08
0	0	0	0	0	0	0	0	0	0	0
0.00E+0	0.00E+0	0.00E+0	2.51E-08	2.01E-07	6.25E-07	1.01E-06	8.59E-07	1.01E-06	1.14E-06	1.14E-06
0.00E+0	0.00E+0	0.00E+0	1.32E-08	1.05E-07	3.28E-07	5.27E-07	4.50E-07	5.31E-07	5.95E-07	5.95E-07
0	0	0	0	0	0	0	0	0	0	0
0.00E+0	0.00E+0	0.00E+0	3.12E-09	2.49E-08	7.75E-08	1.25E-07	1.06E-07	1.26E-07	1.41E-07	1.41E-07
0.00E+0	0.00E+0	0.00E+0	4.55E-09	3.64E-08	1.13E-07	1.82E-07	1.55E-07	1.83E-07	2.06E-07	2.06E-07
0.00E+0	0.00E+0	0.00E+0	5.98E-09	4.79E-08	1.49E-07	2.39E-07	2.04E-07	2.41E-07	2.70E-07	2.70E-07
0	0	0	0	0	0	0	0	0	0	0
0.00E+0	0.00E+0	0.00E+0	1.02E-08	8.14E-08	2.53E-07	4.07E-07	3.47E-07	4.10E-07	4.59E-07	4.59E-07
0.00E+0	0.00E+0	0.00E+0	1.01E-09	8.05E-09	2.50E-08	4.02E-08	3.43E-08	4.05E-08	4.54E-08	4.54E-08
0.00E+0	0.00E+0	0.00E+0	1.67E-08	1.34E-07	4.16E-07	6.69E-07	5.71E-07	6.74E-07	7.55E-07	7.55E-07
0.00E+0	0.00E+0	0.00E+0	1.32E-08	1.05E-07	3.28E-07	5.27E-07	4.50E-07	5.31E-07	5.95E-07	5.95E-07
0.00E+0	0.00E+0	0.00E+0	1.44E-10	1.15E-09	3.58E-09	5.76E-09	4.92E-09	5.80E-09	6.50E-09	6.50E-09
4.16E-01	4.16E-01	4.16E-01	4.16E-01	4.16E-01	3.42E-01	2.68E-01	1.72E-01	1.59E-01	1.45E-01	1.45E-01
0.00E+0	0.00E+0	0.00E+0	5.41E-08	4.33E-07	1.34E-06	2.16E-06	1.85E-06	2.18E-06	2.44E-06	2.44E-06
0.00E+0	0.00E+0	0.00E+0	2.39E-09	1.91E-08	5.95E-08	9.57E-08	8.17E-08	9.64E-08	1.08E-07	1.08E-07
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
3.35E-08	3.35E-08	3.35E-08	3.38E-08	3.61E-08	3.59E-08	3.52E-08	2.55E-08	2.66E-08	2.72E-08	2.72E-08
7.28E-07	7.28E-07	7.28E-07	7.36E-07	7.94E-07	8.05E-07	8.01E-07	5.84E-07	6.14E-07	6.30E-07	6.30E-07
1.39E-02	1.39E-02	1.39E-02	1.40E-02	1.52E-02	1.55E-02	1.56E-02	1.14E-02	1.20E-02	1.24E-02	1.24E-02
1.01E+0	1.01E+0	1.01E+0	1.02E+0	1.02E+0	8.64E-01	7.01E-01	4.60E-01	4.38E-01	4.10E-01	4.10E-01
1.23E-02	1.23E-02	1.23E-02	1.24E-02	1.32E-02	1.29E-02	1.25E-02	8.98E-03	9.32E-03	9.46E-03	9.46E-03
3.91E-05	3.91E-05	3.91E-05	3.95E-05	4.27E-05	4.33E-05	4.31E-05	3.14E-05	3.30E-05	3.39E-05	3.39E-05
3.84E-04	3.84E-04	3.84E-04	3.88E-04	4.20E-04	4.25E-04	4.23E-04	3.09E-04	3.24E-04	3.33E-04	3.33E-04
1.47E-01	1.47E-01	1.47E-01	1.48E-01	1.54E-01	1.44E-01	1.31E-01	9.21E-02	9.35E-02	9.31E-02	9.31E-02
1.16E-02	1.16E-02	1.16E-02	1.17E-02	1.27E-02	1.28E-02	1.27E-02	9.27E-03	9.73E-03	9.98E-03	9.98E-03
1.14E-01	1.14E-01	1.14E-01	1.15E-01	1.20E-01	1.13E-01	1.05E-01	7.38E-02	7.52E-02	7.51E-02	7.51E-02
3.14E-01	3.14E-01	3.14E-01	3.15E-01	3.26E-01	2.95E-01	2.63E-01	1.81E-01	1.81E-01	1.78E-01	1.78E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22	Hour 22

Table H-150: Hourly GWP Emissions from 3-MW ICE in a Typical Day in January (ELF).

Perfluoropentan	0	0	0	0	0	0	0	0	0
Perfluorobutane	0	0	0	0	0	0	0	0	0
Perfluoropropane	0	0	0	0	0	0	0	0	0
Perfluorohexane	0	0	0	0	0	0	0	0	0
Perfluorocyclobut	0	0	0	0	0	0	0	0	0
Perfluoroethane	4.94E-10	4.91E-10	5.06E-10	5.18E-10	5.45E-10	8.02E-10	7.66E-10	7.27E-10	7.20E-10
Perfluoromethane	3.93E-09	3.91E-09	4.03E-09	4.12E-09	4.34E-09	6.38E-09	6.09E-09	5.78E-09	5.73E-09
SF6	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0
HFC-43-10mee	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0
HFC-23	0	0	0	0	0	0	0	0	0
N2O	1.78E-03	1.73E-03	1.74E-03	1.72E-03	1.95E-03	3.52E-03	4.40E-03	4.34E-03	4.33E-03
CH4	4.80E-01	4.77E-01	4.91E-01	5.01E-01	5.30E-01	7.88E-01	7.64E-01	7.26E-01	7.21E-01
CO2	1.08E+0	1.08E+0	1.12E+0	1.15E+0	1.20E+0	1.69E+0	1.50E+0	1.40E+0	1.39E+0
CO2 eq.	1.19E+0	1.18E+0	1.23E+0	1.26E+0	1.31E+0	1.87E+0	1.67E+0	1.57E+0	1.55E+0
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
6.80E-10	6.58E-10	6.58E-10	6.58E-10	6.65E-10	7.11E-10	7.09E-10	6.95E-10	5.04E-10	5.26E-10	5.37E-10
5.41E-09	5.24E-09	5.24E-09	5.24E-09	5.29E-09	5.66E-09	5.64E-09	5.53E-09	4.01E-09	4.19E-09	4.28E-09
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
4.26E-03	4.22E-03	4.22E-03	4.22E-03	4.24E-03	4.32E-03	3.75E-03	3.17E-03	2.13E-03	2.07E-03	1.98E-03
6.83E-01	6.61E-01	6.61E-01	6.61E-01	6.67E-01	7.13E-01	7.04E-01	6.84E-01	4.94E-01	5.14E-01	5.23E-01
1.29E+0	1.24E+0	1.24E+0	1.24E+0	1.25E+0	1.37E+0	1.42E+0	1.45E+0	1.07E+0	1.13E+0	1.17E+0
1.45E+0	1.39E+0	1.39E+0	1.39E+0	1.41E+0	1.53E+0	1.58E+0	1.60E+0	1.18E+0	1.25E+0	1.29E+0
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-151: Hourly Primary Energy Consumption from 3-MW ICE in a Typical Day in January (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	6.02E+02	6.01E+02	2.66E-01	2.12E-01
Hour 4	5.99E+02	5.99E+02	2.65E-01	2.11E-01
hour 5	6.19E+02	6.19E+02	2.74E-01	2.17E-01
Hour 6	6.34E+02	6.34E+02	2.81E-01	2.22E-01
Hour 7	6.65E+02	6.64E+02	2.94E-01	2.34E-01
Hour 8	9.63E+02	9.62E+02	4.27E-01	3.50E-01
Hour 9	8.92E+02	8.92E+02	3.96E-01	3.40E-01
Hour 10	8.42E+02	8.41E+02	3.74E-01	3.23E-01
Hour 11	8.36E+02	8.35E+02	3.71E-01	3.21E-01
Hour 12	7.84E+02	7.83E+02	3.48E-01	3.04E-01
Hour 13	7.55E+02	7.54E+02	3.35E-01	2.95E-01
Hour 14	7.55E+02	7.54E+02	3.35E-01	2.95E-01
Hour 15	7.55E+02	7.54E+02	3.35E-01	2.95E-01
Hour 16	7.63E+02	7.62E+02	3.39E-01	2.97E-01
Hour 17	8.25E+02	8.24E+02	3.66E-01	3.17E-01
Hour 18	8.35E+02	8.35E+02	3.70E-01	3.13E-01
Hour 19	8.31E+02	8.30E+02	3.68E-01	3.03E-01
Hour 20	6.06E+02	6.06E+02	2.69E-01	2.19E-01
Hour 21	6.37E+02	6.36E+02	2.82E-01	2.27E-01
Hour 22	6.54E+02	6.53E+02	2.89E-01	2.31E-01

Table H-152: Hourly Air Emissions from 143-kW ICE in a Typical Day in January (ELF).

Zinc	1.20E-05	1.25E-05	1.36E-05	1.47E-05	1.35E-05	1.11E-05	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Xylene	6.42E-05	6.11E-05	5.96E-05	5.73E-05	6.96E-05	1.45E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04
VOC	2.28E-03	2.37E-03	2.59E-03	2.78E-03	2.57E-03	2.12E-03	0.00E+0	0.00E+0	0.00E+0	0.00E+0
VOC	0	0	0	0	0	0	0	0	0	0
Vanadium	9.63E-07	9.98E-07	1.09E-06	1.17E-06	1.08E-06	8.91E-07	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Toluene	1.84E-04	1.75E-04	1.70E-04	1.64E-04	1.99E-04	4.16E-04	5.95E-04	5.95E-04	5.95E-04	5.95E-04
TOC	5.10E-03	5.24E-03	5.66E-03	6.04E-03	5.71E-03	5.42E-03	1.69E-03	1.69E-03	1.69E-03	1.69E-03
Selenium	9.96E-09	1.03E-08	1.13E-08	1.21E-08	1.12E-08	9.22E-09	0.00E+0	0.00E+0	0.00E+0	0.00E+0
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	8.73E-07	9.05E-07	9.88E-07	1.06E-06	9.81E-07	8.08E-07	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Molybdenu	4.58E-07	4.75E-07	5.18E-07	5.58E-07	5.14E-07	4.24E-07	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	1.08E-07	1.12E-07	1.22E-07	1.32E-07	1.22E-07	1.00E-07	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Manganese	1.58E-07	1.64E-07	1.79E-07	1.93E-07	1.78E-07	1.46E-07	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Lead	2.08E-07	2.15E-07	2.35E-07	2.53E-07	2.33E-07	1.92E-07	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HC	0	0	0	0	0	0	0	0	0	0
Copper	3.53E-07	3.66E-07	4.00E-07	4.30E-07	3.97E-07	3.27E-07	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Cobalt	3.49E-08	3.62E-08	3.95E-08	4.25E-08	3.92E-08	3.23E-08	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Chromium	5.81E-07	6.02E-07	6.57E-07	7.07E-07	6.52E-07	5.38E-07	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Cadmium	4.58E-07	4.75E-07	5.18E-07	5.58E-07	5.14E-07	4.24E-07	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Beryllium	5.00E-09	5.19E-09	5.66E-09	6.09E-09	5.62E-09	4.63E-09	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Benzene	1.28E-01	1.22E-01	1.19E-01	1.15E-01	1.39E-01	2.91E-01	4.16E-01	4.16E-01	4.16E-01	4.16E-01
Barium	1.88E-06	1.95E-06	2.13E-06	2.29E-06	2.11E-06	1.74E-06	0.00E+0	0.00E+0	0.00E+0	0.00E+0
arsenic	8.31E-08	8.62E-08	9.40E-08	1.01E-07	9.33E-08	7.69E-08	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehy	0	0	0	0	0	0	0	0	0	0
NH3	2.47E-08	2.46E-08	2.54E-08	2.59E-08	2.73E-08	3.99E-08	4.16E-08	4.16E-08	4.16E-08	4.16E-08
H2S	5.88E-07	5.84E-07	6.04E-07	6.18E-07	6.49E-07	9.45E-07	9.69E-07	9.69E-07	9.69E-07	9.69E-07
NMVOC	1.15E-02	1.14E-02	1.19E-02	1.22E-02	1.27E-02	1.83E-02	1.84E-02	1.84E-02	1.84E-02	1.84E-02
CO	4.59E-01	4.40E-01	4.34E-01	4.23E-01	4.99E-01	9.82E-01	1.35E+0	1.35E+0	1.35E+0	1.35E+0
Particulates	9.00E-03	8.90E-03	9.16E-03	9.32E-03	9.91E-03	1.51E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02
HF	3.16E-05	3.14E-05	3.25E-05	3.33E-05	3.49E-05	5.08E-05	5.21E-05	5.21E-05	5.21E-05	5.21E-05
HCl	3.10E-04	3.08E-04	3.19E-04	3.26E-04	3.42E-04	4.99E-04	5.11E-04	5.11E-04	5.11E-04	5.11E-04
NOx	9.23E-02	9.06E-02	9.22E-02	9.28E-02	1.01E-01	1.66E-01	1.95E-01	1.95E-01	1.95E-01	1.95E-01
SO2	9.29E-03	9.23E-03	9.54E-03	9.77E-03	1.02E-02	1.49E-02	1.53E-02	1.53E-02	1.53E-02	1.53E-02
SO2	7.39E-02	7.27E-02	7.41E-02	7.47E-02	8.12E-02	1.31E-01	1.52E-01	1.52E-01	1.52E-01	1.52E-01
Ozon	1.82E-01	1.77E-01	1.79E-01	1.79E-01	1.99E-01	3.40E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0.00E+0	0	0	0.00E+0	0.00E+0	1.19E-06	8.02E-06	8.12E-06	1.05E-05	1.25E-05
2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	1.71E-04	1.34E-04	8.59E-05	7.97E-05	7.27E-05
0.00E+0	0	0	0.00E+0	0.00E+0	2.26E-04	1.52E-03	1.54E-03	1.99E-03	2.37E-03
0	0	0	0	0	0	0	0	0	0
0.00E+0	0	0	0.00E+0	0.00E+0	9.51E-08	6.42E-07	6.50E-07	8.40E-07	9.98E-07
5.95E-04	5.95E-04	5.95E-04	5.95E-04	5.95E-04	4.89E-04	3.83E-04	2.46E-04	2.28E-04	2.08E-04
1.69E-03	1.69E-03	1.69E-03	1.69E-03	1.69E-03	1.84E-03	4.14E-03	3.78E-03	4.64E-03	5.34E-03
0.00E+0	0	0	0.00E+0	0.00E+0	9.84E-10	6.64E-09	6.72E-09	8.69E-09	1.03E-08
0	0	0	0	0	0	0	0	0	0
0.00E+0	0	0	0.00E+0	0.00E+0	8.62E-08	5.82E-07	5.89E-07	7.62E-07	9.05E-07
0.00E+0	0	0	0.00E+0	0.00E+0	4.52E-08	3.05E-07	3.09E-07	3.99E-07	4.75E-07
0	0	0	0	0	0	0	0	0	0
0.00E+0	0	0	0.00E+0	0.00E+0	1.07E-08	7.21E-08	7.30E-08	9.44E-08	1.12E-07
0.00E+0	0	0	0.00E+0	0.00E+0	1.56E-08	1.05E-07	1.07E-07	1.38E-07	1.64E-07
0.00E+0	0	0	0.00E+0	0.00E+0	2.05E-08	1.38E-07	1.40E-07	1.81E-07	2.15E-07
0	0	0	0	0	0	0	0	0	0
0.00E+0	0	0	0.00E+0	0.00E+0	3.49E-08	2.35E-07	2.38E-07	3.08E-07	3.66E-07
0.00E+0	0	0	0.00E+0	0.00E+0	3.45E-09	2.33E-08	2.36E-08	3.05E-08	3.62E-08
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	5.74E-08	3.87E-07	3.92E-07	5.07E-07	6.02E-07
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	4.52E-08	3.05E-07	3.09E-07	3.99E-07	4.75E-07
0.00E+0	0	0	0.00E+0	0.00E+0	4.94E-10	3.33E-09	3.38E-09	4.36E-09	5.19E-09
4.16E-01	4.16E-01	4.16E-01	4.16E-01	4.16E-01	3.42E-01	2.68E-01	1.72E-01	1.59E-01	1.45E-01
0.00E+0	0	0	0.00E+0	0.00E+0	1.85E-07	1.25E-06	1.27E-06	1.64E-06	1.95E-06
0.00E+0	0	0	0.00E+0	0.00E+0	8.21E-09	5.54E-08	5.61E-08	7.25E-08	8.62E-08
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4.16E-08	4.16E-08	4.16E-08	4.16E-08	4.16E-08	3.53E-08	3.46E-08	2.52E-08	2.63E-08	2.69E-08
9.69E-07	9.69E-07	9.69E-07	9.69E-07	9.69E-07	8.24E-07	8.16E-07	5.95E-07	6.23E-07	6.38E-07
1.84E-02	1.84E-02	1.84E-02	1.84E-02	1.84E-02	1.57E-02	1.57E-02	1.15E-02	1.21E-02	1.25E-02
1.35E+0	1.35E+0	1.35E+0	1.35E+0	1.35E+0	1.11E+0	8.96E-01	5.85E-01	5.53E-01	5.15E-01
1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.38E-02	1.31E-02	9.40E-03	9.70E-03	9.81E-03
5.21E-05	5.21E-05	5.21E-05	5.21E-05	5.21E-05	4.44E-05	4.39E-05	3.20E-05	3.35E-05	3.43E-05
5.11E-04	5.11E-04	5.11E-04	5.11E-04	5.11E-04	4.35E-04	4.31E-04	3.14E-04	3.29E-04	3.37E-04
1.95E-01	1.95E-01	1.95E-01	1.95E-01	1.95E-01	1.63E-01	1.47E-01	1.02E-01	1.03E-01	1.02E-01
1.53E-02	1.53E-02	1.53E-02	1.53E-02	1.53E-02	1.31E-02	1.29E-02	9.41E-03	9.85E-03	1.01E-02
1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.27E-01	1.16E-01	8.09E-02	8.17E-02	8.11E-02
4.17E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01	3.48E-01	3.03E-01	2.08E-01	2.06E-01	2.01E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-153: Hourly GWP Emissions from 143-kW ICE in a Typical Day in January (ELF).

Perfluoropent	0	0	0	0	0	0	0	0	0
Perfluorobuta	0	0	0	0	0	0	0	0	0
Perfluoroprop	0	0	0	0	0	0	0	0	0
Perfluorohexa	0	0	0	0	0	0	0	0	0
Perfluorocycl	0	0	0	0	0	0	0	0	0
Perfluoroetha	4.90E-10	4.87E-10	5.03E-10	5.14E-10	5.41E-10	7.93E-10	8.24E-10	8.24E-10	8.24E-10
Perfluoromet	3.90E-09	3.87E-09	4.00E-09	4.09E-09	4.31E-09	6.31E-09	6.55E-09	6.55E-09	6.55E-09
SF6	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0
HFC-43-	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0
HFC-23	0	0	0	0	0	0	0	0	0
N2O	2.13E-03	2.06E-03	2.05E-03	2.02E-03	2.32E-03	4.29E-03	5.62E-03	5.62E-03	5.62E-03
CH4	4.96E-01	4.91E-01	5.06E-01	5.15E-01	5.46E-01	8.23E-01	8.80E-01	8.80E-01	8.80E-01
CO2	1.08E+0	1.07E+0	1.11E+0	1.15E+0	1.19E+0	1.68E+0	1.65E+0	1.65E+0	1.65E+0
CO2 eq.	1.19E+0	1.18E+0	1.23E+0	1.26E+0	1.31E+0	1.86E+0	1.85E+0	1.85E+0	1.85E+0
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
8.24E-10	8.24E-10	8.24E-10	8.24E-10	8.24E-10	8.24E-10	6.99E-10	6.87E-10	4.99E-10	5.21E-10	5.33E-10
6.55E-09	6.55E-09	6.55E-09	6.55E-09	6.55E-09	6.55E-09	5.56E-09	5.46E-09	3.97E-09	4.14E-09	4.24E-09
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
5.62E-03	5.62E-03	5.62E-03	5.62E-03	5.62E-03	5.62E-03	4.66E-03	3.88E-03	2.58E-03	2.49E-03	2.37E-03
8.80E-01	8.80E-01	8.80E-01	8.80E-01	8.80E-01	8.80E-01	7.45E-01	7.16E-01	5.15E-01	5.33E-01	5.40E-01
1.65E+0	1.65E+0	1.65E+0	1.65E+0	1.65E+0	1.65E+0	1.41E+0	1.44E+0	1.06E+0	1.13E+0	1.16E+0
1.85E+0	1.85E+0	1.85E+0	1.85E+0	1.85E+0	1.85E+0	1.58E+0	1.60E+0	1.18E+0	1.25E+0	1.29E+0
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-154: Hourly Primary Energy Consumption from 143-kW ICE in a Typical Day in January (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	6.10E+02	6.09E+02	2.70E-01	2.08E-01
Hour 4	6.06E+02	6.05E+02	2.68E-01	2.07E-01
hour 5	6.27E+02	6.26E+02	2.77E-01	2.13E-01
Hour 6	6.41E+02	6.41E+02	2.84E-01	2.18E-01
Hour 7	6.73E+02	6.72E+02	2.98E-01	2.30E-01
Hour 8	9.80E+02	9.79E+02	4.34E-01	3.39E-01
Hour 9	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 10	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 11	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 12	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 13	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 14	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 15	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 16	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 17	1.00E+03	1.00E+03	4.45E-01	3.54E-01
Hour 18	8.56E+02	8.55E+02	3.79E-01	3.01E-01
Hour 19	8.46E+02	8.46E+02	3.75E-01	2.94E-01
Hour 20	6.17E+02	6.17E+02	2.73E-01	2.13E-01
Hour 21	6.46E+02	6.46E+02	2.86E-01	2.22E-01
Hour 22	6.62E+02	6.61E+02	2.93E-01	2.26E-01

Table H-155: Hourly Air Emissions from SOFC (EC) in a Typical Day in May (ELF).

Zinc	0	0	0	0	0	0	0	0	0	0
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
Vanadium	0	0	0	0	0	0	0	0	0	0
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	0	0	0	0	0	0	0	0	0	0
Selenium	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	0	0	0	0	0	0	0	0	0	0
Molybdenu	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	0	0	0	0	0	0	0	0	0	0
Manganese	0	0	0	0	0	0	0	0	0	0
Lead	0	0	0	0	0	0	0	0	0	0
HC	0	0	0	0	0	0	0	0	0	0
Copper	0	0	0	0	0	0	0	0	0	0
Cobalt	0	0	0	0	0	0	0	0	0	0
Chromium	0	0	0	0	0	0	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0	0	0
Beryllium	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0
Barium	0	0	0	0	0	0	0	0	0	0
arsenic	0	0	0	0	0	0	0	0	0	0
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehy	0	0	0	0	0	0	0	0	0	0
NH3	6.41E-09	6.02E-09	5.74E-09	5.45E-09	6.88E-09	2.11E-08	3.19E-08	3.26E-08	3.44E-08	3.56E-08
H2S	1.50E-07	1.41E-07	1.35E-07	1.28E-07	1.62E-07	4.84E-07	7.23E-07	7.37E-07	7.72E-07	7.94E-07
NMVOC	5.40E-04	5.08E-04	4.84E-04	4.60E-04	5.81E-04	1.74E-03	2.60E-03	2.65E-03	2.78E-03	2.86E-03
CO	4.64E-03	4.36E-03	4.15E-03	3.95E-03	4.99E-03	1.51E-02	2.26E-02	2.30E-02	2.42E-02	2.49E-02
Particulates	4.77E-04	4.49E-04	4.27E-04	4.06E-04	5.13E-04	1.54E-03	2.31E-03	2.36E-03	2.48E-03	2.55E-03
HF	9.35E-06	8.79E-06	8.37E-06	7.95E-06	1.00E-05	3.01E-05	4.50E-05	4.58E-05	4.81E-05	4.94E-05
HCl	8.17E-05	7.68E-05	7.31E-05	6.95E-05	8.78E-05	2.63E-04	3.93E-04	4.01E-04	4.20E-04	4.32E-04
NOx	5.98E-03	5.62E-03	5.35E-03	5.09E-03	6.42E-03	1.93E-02	2.88E-02	2.93E-02	3.08E-02	3.16E-02
SO2	2.33E-03	2.19E-03	2.09E-03	1.99E-03	2.51E-03	7.53E-03	1.13E-02	1.15E-02	1.20E-02	1.24E-02
SO2 eq.	6.58E-03	6.19E-03	5.89E-03	5.60E-03	7.07E-03	2.12E-02	3.17E-02	3.23E-02	3.39E-02	3.49E-02
TOPP eq.	9.97E-03	9.38E-03	8.93E-03	8.48E-03	1.07E-02	3.21E-02	4.81E-02	4.89E-02	5.13E-02	5.28E-02
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
3.51E-08	3.49E-08	3.46E-08	3.64E-08	3.71E-08	3.19E-08	2.51E-08	1.58E-08	1.11E-08	8.37E-09
7.85E-07	7.81E-07	7.76E-07	8.09E-07	8.24E-07	7.04E-07	5.53E-07	3.47E-07	2.50E-07	1.93E-07
2.82E-03	2.81E-03	2.79E-03	2.91E-03	2.96E-03	2.53E-03	1.99E-03	1.25E-03	8.99E-04	6.93E-04
2.46E-02	2.45E-02	2.43E-02	2.54E-02	2.59E-02	2.22E-02	1.74E-02	1.09E-02	7.81E-03	5.99E-03
2.52E-03	2.50E-03	2.49E-03	2.60E-03	2.65E-03	2.26E-03	1.78E-03	1.12E-03	8.00E-04	6.14E-04
4.89E-05	4.86E-05	4.83E-05	5.04E-05	5.13E-05	4.38E-05	3.44E-05	2.16E-05	1.56E-05	1.20E-05
4.27E-04	4.25E-04	4.22E-04	4.40E-04	4.48E-04	3.83E-04	3.01E-04	1.89E-04	1.36E-04	1.05E-04
3.13E-02	3.11E-02	3.09E-02	3.23E-02	3.28E-02	2.80E-02	2.21E-02	1.38E-02	9.96E-03	7.67E-03
1.22E-02	1.22E-02	1.21E-02	1.26E-02	1.28E-02	1.10E-02	8.63E-03	5.42E-03	3.90E-03	3.00E-03
3.45E-02	3.43E-02	3.41E-02	3.55E-02	3.62E-02	3.09E-02	2.43E-02	1.53E-02	1.10E-02	8.45E-03
5.22E-02	5.19E-02	5.16E-02	5.38E-02	5.48E-02	4.68E-02	3.68E-02	2.31E-02	1.66E-02	1.28E-02
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-156: Hourly GWP Emissions from SOFC (EC) in a Typical Day in May (ELF).

Perfluoropentan	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Perfluorobutane	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Perfluoropropane	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Perfluorohexane	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Perfluorocyclobut	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Perfluoroethane	6.70E-08	6.30E-08	6.00E-08	5.70E-08	7.20E-08	2.16E-07	3.22E-07	3.28E-07	3.44E-07
Perfluoromethane	5.33E-07	5.01E-07	4.78E-07	4.54E-07	5.73E-07	1.71E-06	2.56E-06	2.61E-06	2.74E-06
SF6	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-245	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-236	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-227	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-143a	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-143	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-152a	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-134a	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-134	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-125	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-43-10mee	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-32	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
HFC-23	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
N2O	6.56E-05	6.17E-05	5.88E-05	5.58E-05	7.05E-05	2.11E-04	3.16E-04	3.22E-04	3.37E-04
CH4	1.16E-01	1.09E-01	1.04E-01	9.90E-02	1.25E-01	3.74E-01	5.60E-01	5.70E-01	5.98E-01
CO2	2.95E+0	2.78E+0	2.64E+0	2.51E+0	3.17E+0	9.50E+0	1.42E+0	1.45E+0	1.52E+0
CO2 eq.	3.20E+0	3.01E+0	2.87E+0	2.72E+0	3.44E+0	1.03E+0	1.54E+0	1.57E+0	1.64E+0
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
3.54E-07	3.50E-07	3.48E-07	3.46E-07	3.61E-07	3.67E-07	3.14E-07	2.47E-07	1.55E-07	1.11E-07	8.59E-08
2.82E-06	2.78E-06	2.77E-06	2.75E-06	2.87E-06	2.92E-06	2.49E-06	1.96E-06	1.23E-06	8.87E-07	6.83E-07
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
3.47E-04	3.43E-04	3.41E-04	3.39E-04	3.54E-04	3.60E-04	3.07E-04	2.42E-04	1.52E-04	1.09E-04	8.42E-05
6.15E-01	6.08E-01	6.04E-01	6.01E-01	6.26E-01	6.37E-01	5.45E-01	4.28E-01	2.69E-01	1.94E-01	1.49E-01
1.56E+0	1.54E+0	1.53E+0	1.52E+0	1.59E+0	1.62E+0	1.38E+0	1.09E+0	6.82E+0	4.91E+0	3.78E+0
1.69E+0	1.67E+0	1.66E+0	1.65E+0	1.72E+0	1.75E+0	1.50E+0	1.18E+0	7.39E+0	5.32E+0	4.10E+0
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-157: Hourly Primary Energy Consumption from SOFC (EC) in a Typical Day in May (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	1.56E+02	1.56E+02	7.54E-02	5.53E-02
Hour 4	1.47E+02	1.47E+02	7.09E-02	5.20E-02
hour 5	1.40E+02	1.40E+02	6.76E-02	4.95E-02
Hour 6	1.33E+02	1.33E+02	6.42E-02	4.70E-02
Hour 7	1.68E+02	1.67E+02	8.11E-02	5.94E-02
Hour 8	5.02E+02	5.02E+02	2.43E-01	1.82E-01
Hour 9	7.51E+02	7.50E+02	3.63E-01	2.74E-01
Hour 10	7.65E+02	7.64E+02	3.70E-01	2.79E-01
Hour 11	8.02E+02	8.01E+02	3.88E-01	2.95E-01
Hour 12	8.25E+02	8.24E+02	3.99E-01	3.04E-01
Hour 13	8.15E+02	8.14E+02	3.95E-01	3.00E-01
Hour 14	8.11E+02	8.10E+02	3.93E-01	2.98E-01
Hour 15	8.06E+02	8.05E+02	3.90E-01	2.96E-01
Hour 16	8.40E+02	8.40E+02	4.07E-01	3.11E-01
Hour 17	8.55E+02	8.54E+02	4.14E-01	3.17E-01
Hour 18	7.30E+02	7.30E+02	3.54E-01	2.72E-01
Hour 19	5.74E+02	5.74E+02	2.78E-01	2.14E-01
Hour 20	3.60E+02	3.60E+02	1.75E-01	1.34E-01
Hour 21	2.60E+02	2.59E+02	1.26E-01	9.47E-02
Hour 22	2.00E+02	2.00E+02	9.68E-02	7.20E-02

Table H-158: Hourly Air Emissions from SOFC (AC/EC) in a Typical Day in May (ELF).

Zinc	0	0	0	0	0	0	0	0	0	0
Xylene	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
Vanadium	0	0	0	0	0	0	0	0	0	0
Toluene	0	0	0	0	0	0	0	0	0	0
TOC	0	0	0	0	0	0	0	0	0	0
Selenium	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0
Nickel	0	0	0	0	0	0	0	0	0	0
Molybdenum	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0
Mercury	0	0	0	0	0	0	0	0	0	0
Manganese	0	0	0	0	0	0	0	0	0	0
Lead	0	0	0	0	0	0	0	0	0	0
HC	0	0	0	0	0	0	0	0	0	0
Copper	0	0	0	0	0	0	0	0	0	0
Cobalt	0	0	0	0	0	0	0	0	0	0
Chromium	0	0	0	0	0	0	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0	0	0
Beryllium	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0
Barium	0	0	0	0	0	0	0	0	0	0
arsenic	0	0	0	0	0	0	0	0	0	0
Acrolein	0	0	0	0	0	0	0	0	0	0
Acetaldehyd	0	0	0	0	0	0	0	0	0	0
NH3	6.41E-09	6.02E-09	5.74E-09	5.45E-09	6.88E-09	1.86E-08	2.76E-08	2.81E-08	2.94E-08	3.04E-08
H2S	1.50E-07	1.41E-07	1.35E-07	1.28E-07	1.62E-07	4.38E-07	6.49E-07	6.60E-07	6.91E-07	7.14E-07
NMVOC	5.40E-04	5.08E-04	4.84E-04	4.60E-04	5.81E-04	1.57E-03	2.33E-03	2.37E-03	2.48E-03	2.57E-03
CO	4.64E-03	4.36E-03	4.15E-03	3.95E-03	4.99E-03	1.35E-02	2.00E-02	2.04E-02	2.13E-02	2.20E-02
Particulates	4.77E-04	4.49E-04	4.27E-04	4.06E-04	5.13E-04	1.39E-03	2.06E-03	2.10E-03	2.20E-03	2.27E-03
HF	9.35E-06	8.79E-06	8.37E-06	7.95E-06	1.00E-05	2.72E-05	4.04E-05	4.11E-05	4.30E-05	4.44E-05
HCl	8.17E-05	7.68E-05	7.31E-05	6.95E-05	8.78E-05	2.38E-04	3.53E-04	3.59E-04	3.76E-04	3.88E-04
NOx	5.98E-03	5.62E-03	5.35E-03	5.09E-03	6.42E-03	1.74E-02	2.58E-02	2.63E-02	2.75E-02	2.84E-02
SO2	2.33E-03	2.19E-03	2.09E-03	1.99E-03	2.51E-03	6.80E-03	1.01E-02	1.03E-02	1.07E-02	1.11E-02
SO2 eq.	6.58E-03	6.19E-03	5.89E-03	5.60E-03	7.07E-03	1.92E-02	2.84E-02	2.89E-02	3.03E-02	3.13E-02
TOPP eq.	9.97149E	9.37618E	8.92969E	8.48321E	1.07156E	2.90457E	4.30472E	4.37917E	4.58754E	4.73640E
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
2.99E-08	2.98E-08	2.96E-08	3.09E-08	3.14E-08	2.68E-08	2.11E-08	1.33E-08	9.54E-09	7.46E-09
7.03E-07	7.00E-07	6.96E-07	7.27E-07	7.39E-07	6.31E-07	4.96E-07	3.12E-07	2.25E-07	1.75E-07
2.53E-03	2.52E-03	2.50E-03	2.61E-03	2.65E-03	2.27E-03	1.78E-03	1.12E-03	8.07E-04	6.29E-04
2.17E-02	2.16E-02	2.15E-02	2.25E-02	2.28E-02	1.95E-02	1.53E-02	9.63E-03	6.93E-03	5.40E-03
2.23E-03	2.22E-03	2.21E-03	2.31E-03	2.34E-03	2.00E-03	1.57E-03	9.91E-04	7.13E-04	5.55E-04
4.37E-05	4.36E-05	4.33E-05	4.53E-05	4.60E-05	3.93E-05	3.09E-05	1.94E-05	1.40E-05	1.09E-05
3.82E-04	3.81E-04	3.78E-04	3.95E-04	4.02E-04	3.43E-04	2.70E-04	1.70E-04	1.22E-04	9.51E-05
2.79E-02	2.79E-02	2.77E-02	2.89E-02	2.94E-02	2.51E-02	1.97E-02	1.24E-02	8.93E-03	6.96E-03
1.09E-02	1.09E-02	1.08E-02	1.13E-02	1.15E-02	9.80E-03	7.71E-03	4.85E-03	3.49E-03	2.72E-03
3.08E-02	3.07E-02	3.05E-02	3.19E-02	3.24E-02	2.76E-02	2.17E-02	1.37E-02	9.83E-03	7.66E-03
4.66197E	4.64708E	4.61731E	4.82571E	4.90014E	4.18516E	3.29152E	2.07022E	1.48952E	1.16086E
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-159: Hourly GWP Emissions from SOFC (AC/EC) in a Typical Day in May (ELF).

Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
CO2 eq.	3.20E+0	3.01E+0	2.87E+0	2.72E+0	3.44E+0	9.31E+0	1.38E+0	1.40E+0	1.47E+0
CO2	2.95E+0	2.78E+0	2.64E+0	2.51E+0	3.17E+0	8.60E+0	1.27E+0	1.30E+0	1.36E+0
CH4	1.16E-01	1.09E-01	1.04E-01	9.90E-02	1.25E-01	3.39E-01	5.02E-01	5.11E-01	5.35E-01
N2O	6.56E-05	6.17E-05	5.88E-05	5.58E-05	7.05E-05	1.91E-04	2.83E-04	2.88E-04	3.02E-04
HFC-23	0	0	0	0	0	0	0	0	0
HFC-32	0	0	0	0	0	0	0	0	0
HFC-43-	0	0	0	0	0	0	0	0	0
HFC-125	0	0	0	0	0	0	0	0	0
HFC-134	0	0	0	0	0	0	0	0	0
HFC-134a	0	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0	0
HFC-143	0	0	0	0	0	0	0	0	0
HFC-143a	0	0	0	0	0	0	0	0	0
HFC-227	0	0	0	0	0	0	0	0	0
HFC-236	0	0	0	0	0	0	0	0	0
HFC-245	0	0	0	0	0	0	0	0	0
SF6	0	0	0	0	0	0	0	0	0
Perfluoromet	5.33E-07	5.01E-07	4.78E-07	4.54E-07	5.73E-07	1.55E-06	2.30E-06	2.34E-06	2.45E-06
Perfluoroeth	6.70E-08	6.30E-08	6.00E-08	5.70E-08	7.20E-08	1.95E-07	2.89E-07	2.94E-07	3.08E-07
Perfluorocyc	0	0	0	0	0	0	0	0	0
Perfluorohex	0	0	0	0	0	0	0	0	0
Perfluoropro	0	0	0	0	0	0	0	0	0
Perfluorobut	0	0	0	0	0	0	0	0	0
Perfluoropen	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
3.18E-07	3.13E-07	3.12E-07	3.10E-07	3.24E-07	3.29E-07	2.81E-07	2.21E-07	1.39E-07	1.00E-07	7.80E-08
2.53E-06	2.49E-06	2.48E-06	2.47E-06	2.58E-06	2.62E-06	2.24E-06	1.76E-06	1.11E-06	7.96E-07	6.21E-07
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
3.12E-04	3.07E-04	3.06E-04	3.04E-04	3.18E-04	3.22E-04	2.75E-04	2.17E-04	1.36E-04	9.80E-05	7.64E-05
5.52E-01	5.44E-01	5.42E-01	5.39E-01	5.63E-01	5.72E-01	4.88E-01	3.84E-01	2.41E-01	1.74E-01	1.35E-01
1.40E+02	1.38E+02	1.38E+02	1.37E+02	1.43E+02	1.45E+02	1.24E+02	9.74E+01	6.13E+01	4.41E+01	3.44E+01
1.52E+02	1.50E+02	1.49E+02	1.48E+02	1.55E+02	1.57E+02	1.34E+02	1.06E+02	6.64E+01	4.78E+01	3.73E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-160: Hourly Primary Energy Consumption from SOFC (AC/EC) in a Typical Day in May (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	1.6E+02	1.6E+02	7.5E-02	5.5E-02
Hour 4	1.5E+02	1.5E+02	7.1E-02	5.2E-02
hour 5	1.4E+02	1.4E+02	6.8E-02	4.9E-02
Hour 6	1.3E+02	1.3E+02	6.4E-02	4.7E-02
Hour 7	1.7E+02	1.7E+02	8.1E-02	5.9E-02
Hour 8	4.5E+02	4.5E+02	2.2E-01	1.6E-01
Hour 9	6.7E+02	6.7E+02	3.3E-01	2.4E-01
Hour 10	6.9E+02	6.8E+02	3.3E-01	2.4E-01
Hour 11	7.2E+02	7.2E+02	3.5E-01	2.5E-01
Hour 12	7.4E+02	7.4E+02	3.6E-01	2.6E-01
Hour 13	7.3E+02	7.3E+02	3.5E-01	2.6E-01
Hour 14	7.3E+02	7.3E+02	3.5E-01	2.6E-01
Hour 15	7.2E+02	7.2E+02	3.5E-01	2.6E-01
Hour 16	7.6E+02	7.5E+02	3.7E-01	2.7E-01
Hour 17	7.7E+02	7.7E+02	3.7E-01	2.7E-01
Hour 18	6.5E+02	6.5E+02	3.2E-01	2.3E-01
Hour 19	5.2E+02	5.1E+02	2.5E-01	1.8E-01
Hour 20	3.2E+02	3.2E+02	1.6E-01	1.1E-01
Hour 21	2.3E+02	2.3E+02	1.1E-01	8.3E-02
Hour 22	1.8E+02	1.8E+02	8.8E-02	6.4E-02

Table H-161: Hourly Air Emissions from Microturbine (EC) in a Typical Day in May (ELF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
TOPP eq.	3.90E-02	3.66E-02	3.49E-02	3.32E-02	4.19E-02	1.25E-01	1.88E-01	1.91E-01	2.00E-01
SO2 eq.	2.16E-02	2.03E-02	1.93E-02	1.84E-02	2.32E-02	6.94E-02	1.04E-01	1.06E-01	1.11E-01
SO2	4.14E-03	3.89E-03	3.71E-03	3.52E-03	4.45E-03	1.33E-02	2.00E-02	2.03E-02	2.13E-02
NOx	2.48E-02	2.34E-02	2.22E-02	2.11E-02	2.67E-02	7.99E-02	1.20E-01	1.22E-01	1.28E-01
HCl	1.33E-04	1.25E-04	1.19E-04	1.13E-04	1.43E-04	4.29E-04	6.41E-04	6.53E-04	6.85E-04
HF	1.36E-05	1.28E-05	1.21E-05	1.15E-05	1.46E-05	4.37E-05	6.53E-05	6.65E-05	6.98E-05
Particulates	7.23E-04	6.80E-04	6.47E-04	6.15E-04	7.77E-04	2.34E-03	3.50E-03	3.56E-03	3.74E-03
CO	4.72E-02	4.44E-02	4.23E-02	4.02E-02	5.08E-02	1.52E-01	2.27E-01	2.32E-01	2.43E-01
NMVOC	7.37E-04	6.93E-04	6.60E-04	6.27E-04	7.92E-04	2.37E-03	3.55E-03	3.61E-03	3.79E-03
H2S	2.52E-07	2.37E-07	2.26E-07	2.15E-07	2.71E-07	8.12E-07	1.21E-06	1.24E-06	1.30E-06
NH3	1.07E-08	1.01E-08	9.61E-09	9.13E-09	1.15E-08	3.51E-08	5.27E-08	5.38E-08	5.66E-08
Acetaldehyde	0	0	0	0	0	0	0	0	0
Acrolein	0	0	0	0	0	0	0	0	0
arsenic	0	0	0	0	0	0	0	0	0
Barium	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0
Beryllium	0	0	0	0	0	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0	0
Chromium	0	0	0	0	0	0	0	0	0
Cobalt	0	0	0	0	0	0	0	0	0
Copper	0	0	0	0	0	0	0	0	0
HC	5.20E-03	4.89E-03	4.65E-03	4.42E-03	5.58E-03	1.67E-02	2.50E-02	2.54E-02	2.67E-02
Lead	0	0	0	0	0	0	0	0	0
Manganese	0	0	0	0	0	0	0	0	0
Mercury	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0
Molybdenum	0	0	0	0	0	0	0	0	0
Nickel	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0
Selenium	0	0	0	0	0	0	0	0	0
TOC	0	0	0	0	0	0	0	0	0
Toluene	0	0	0	0	0	0	0	0	0
Vanadium	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0
Xylene	0	0	0	0	0	0	0	0	0
Zinc	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
2.74E-02	2.71E-02	2.70E-02	2.68E-02	2.80E-02	2.84E-02	2.43E-02	1.91E-02	1.20E-02	8.64E-03	6.66E-03
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
5.83E-08	5.76E-08	5.73E-08	5.69E-08	5.95E-08	6.07E-08	5.20E-08	4.09E-08	2.58E-08	1.82E-08	1.39E-08
1.33E-06	1.32E-06	1.31E-06	1.30E-06	1.36E-06	1.38E-06	1.18E-06	9.29E-07	5.83E-07	4.20E-07	3.23E-07
3.90E-03	3.85E-03	3.83E-03	3.81E-03	3.97E-03	4.04E-03	3.45E-03	2.72E-03	1.70E-03	1.23E-03	9.45E-04
2.50E-01	2.47E-01	2.46E-01	2.44E-01	2.55E-01	2.59E-01	2.21E-01	1.74E-01	1.09E-01	7.86E-02	6.06E-02
3.85E-03	3.80E-03	3.78E-03	3.76E-03	3.92E-03	3.99E-03	3.41E-03	2.68E-03	1.68E-03	1.21E-03	9.30E-04
7.17E-05	7.09E-05	7.06E-05	7.01E-05	7.31E-05	7.44E-05	6.36E-05	5.00E-05	3.14E-05	2.26E-05	1.74E-05
7.04E-04	6.96E-04	6.92E-04	6.88E-04	7.18E-04	7.30E-04	6.24E-04	4.91E-04	3.08E-04	2.22E-04	1.71E-04
1.31E-01	1.30E-01	1.29E-01	1.28E-01	1.34E-01	1.36E-01	1.16E-01	9.14E-02	5.74E-02	4.13E-02	3.18E-02
2.19E-02	2.17E-02	2.16E-02	2.14E-02	2.24E-02	2.28E-02	1.94E-02	1.53E-02	9.59E-03	6.90E-03	5.32E-03
1.14E-01	1.13E-01	1.12E-01	1.11E-01	1.16E-01	1.18E-01	1.01E-01	7.95E-02	4.99E-02	3.59E-02	2.77E-02
2.06E-01	2.04E-01	2.03E-01	2.01E-01	2.10E-01	2.14E-01	1.82E-01	1.43E-01	9.00E-02	6.48E-02	5.00E-02
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-162: Hourly GWP Emissions from Microturbine (EC) in a Typical Day in May (ELF).

Perfluoropen	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobut	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohex	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocycl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoretha	2.1E-10	2.0E-10	1.9E-10	1.8E-10	2.3E-10	6.9E-10	1.0E-09	1.1E-09	1.1E-09
Perfluoromet	1.7E-09	1.6E-09	1.5E-09	1.4E-09	1.8E-09	5.5E-09	8.3E-09	8.5E-09	8.9E-09
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.1E-04	1.0E-04	9.8E-05	9.3E-05	1.2E-04	3.5E-04	5.3E-04	5.4E-04	5.6E-04
CH4	2.0E-01	1.8E-01	1.7E-01	1.7E-01	2.1E-01	6.3E-01	9.4E-01	9.6E-01	1.0E+00
CO2	5.1E+01	4.8E+01	4.5E+01	4.3E+01	5.4E+01	1.6E+02	2.4E+02	2.5E+02	2.6E+02
CO2 eq.	5.5E+01	5.2E+01	4.9E+01	4.7E+01	5.9E+01	1.8E+02	2.6E+02	2.7E+02	2.8E+02
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
1.2E-09	1.1E-09	1.1E-09	1.1E-09	1.2E-09	1.2E-09	1.0E-09	8.1E-10	5.1E-10	3.6E-10	2.8E-10
9.2E-09	9.1E-09	9.0E-09	8.9E-09	9.4E-09	9.5E-09	8.2E-09	6.4E-09	4.0E-09	2.9E-09	2.2E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.8E-04	5.7E-04	5.7E-04	5.6E-04	5.9E-04	6.0E-04	5.1E-04	4.0E-04	2.5E-04	1.8E-04	1.4E-04
1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.1E+00	1.1E+00	9.1E-01	7.2E-01	4.5E-01	3.2E-01	2.5E-01
2.7E+02	2.6E+02	2.6E+02	2.6E+02	2.7E+02	2.8E+02	2.4E+02	1.9E+02	1.2E+02	8.4E+01	6.5E+01
2.9E+02	2.9E+02	2.8E+02	2.8E+02	2.9E+02	3.0E+02	2.6E+02	2.0E+02	1.3E+02	9.1E+01	7.0E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-163: Hourly Primary Energy Consumption from Microturbine (EC) in a Typical Day in May (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.62E+02	2.61E+02	1.16E-01	9.09E-02
Hour 4	2.46E+02	2.46E+02	1.09E-01	8.54E-02
Hour 5	2.34E+02	2.34E+02	1.04E-01	8.14E-02
Hour 6	2.23E+02	2.22E+02	9.85E-02	7.73E-02
Hour 7	2.81E+02	2.81E+02	1.24E-01	9.76E-02
Hour 8	8.43E+02	8.42E+02	3.73E-01	2.96E-01
Hour 9	1.26E+03	1.26E+03	5.58E-01	4.45E-01
Hour 10	1.28E+03	1.28E+03	5.68E-01	4.54E-01
Hour 11	1.35E+03	1.34E+03	5.96E-01	4.78E-01
Hour 12	1.38E+03	1.38E+03	6.13E-01	4.92E-01
Hour 13	1.37E+03	1.37E+03	6.05E-01	4.86E-01
Hour 14	1.36E+03	1.36E+03	6.02E-01	4.83E-01
Hour 15	1.35E+03	1.35E+03	5.99E-01	4.80E-01
Hour 16	1.41E+03	1.41E+03	6.24E-01	5.02E-01
Hour 17	1.43E+03	1.43E+03	6.35E-01	5.12E-01
Hour 18	1.23E+03	1.22E+03	5.43E-01	4.38E-01
Hour 19	9.64E+02	9.63E+02	4.27E-01	3.45E-01
Hour 20	6.05E+02	6.04E+02	2.68E-01	2.16E-01
Hour 21	4.36E+02	4.35E+02	1.93E-01	1.54E-01
Hour 22	3.36E+02	3.35E+02	1.49E-01	1.18E-01

Table H-164: Hourly Air Emissions from Microturbine (AC/EC) in a Typical Day in May (ELF).

Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenum	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	5.2E-03	4.9E-03	4.7E-03	4.4E-03	5.6E-03	1.5E-02	2.1E-02	2.1E-02	2.1E-02	2.1E-02
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehyde	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	1.1E-08	1.0E-08	9.6E-09	9.1E-09	1.2E-08	3.0E-08	4.3E-08	4.3E-08	4.3E-08	4.3E-08
H2S	2.5E-07	2.4E-07	2.3E-07	2.1E-07	2.7E-07	7.1E-07	1.0E-06	1.0E-06	1.0E-06	1.0E-06
NMVOC	7.4E-04	6.9E-04	6.6E-04	6.3E-04	7.9E-04	2.1E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03
CO	4.7E-02	4.4E-02	4.2E-02	4.0E-02	5.1E-02	1.3E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01
Particulates	7.2E-04	6.8E-04	6.5E-04	6.1E-04	7.8E-04	2.0E-03	2.9E-03	2.9E-03	2.9E-03	2.9E-03
HF	1.4E-05	1.3E-05	1.2E-05	1.2E-05	1.5E-05	3.8E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05
HCl	1.3E-04	1.3E-04	1.2E-04	1.1E-04	1.4E-04	3.7E-04	5.3E-04	5.3E-04	5.3E-04	5.3E-04
NOx	2.5E-02	2.3E-02	2.2E-02	2.1E-02	2.7E-02	7.0E-02	1.0E-01	1.0E-01	1.0E-01	1.0E-01
SO2	4.1E-03	3.9E-03	3.7E-03	3.5E-03	4.5E-03	1.2E-02	1.7E-02	1.7E-02	1.7E-02	1.7E-02
SO2	2.2E-02	2.0E-02	1.9E-02	1.8E-02	2.3E-02	6.1E-02	8.7E-02	8.7E-02	8.7E-02	8.7E-02
TOPP eq.	3.9E-02	3.7E-02	3.5E-02	3.3E-02	4.2E-02	1.1E-01	1.6E-01	1.6E-01	1.6E-01	1.6E-01
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.1E-02	2.1E-02	2.1E-02	2.1E-02	2.1E-02	1.7E-02	1.3E-02	8.4E-03	7.1E-03	6.0E-03
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.3E-08	4.3E-08	4.3E-08	4.3E-08	4.3E-08	3.5E-08	2.8E-08	1.7E-08	1.5E-08	1.2E-08
1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	8.3E-07	6.5E-07	4.1E-07	3.5E-07	2.9E-07
3.0E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03	2.4E-03	1.9E-03	1.2E-03	1.0E-03	8.6E-04
1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.6E-01	1.2E-01	7.6E-02	6.5E-02	5.5E-02
2.9E-03	2.9E-03	2.9E-03	2.9E-03	2.9E-03	2.4E-03	1.9E-03	1.2E-03	9.9E-04	8.4E-04
5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05	4.5E-05	3.5E-05	2.2E-05	1.9E-05	1.6E-05
5.3E-04	5.3E-04	5.3E-04	5.3E-04	5.3E-04	4.4E-04	3.4E-04	2.2E-04	1.8E-04	1.5E-04
1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01	8.2E-02	6.4E-02	4.0E-02	3.4E-02	2.9E-02
1.7E-02	1.7E-02	1.7E-02	1.7E-02	1.7E-02	1.4E-02	1.1E-02	6.7E-03	5.7E-03	4.8E-03
8.7E-02	8.7E-02	8.7E-02	8.7E-02	8.7E-02	7.1E-02	5.6E-02	3.5E-02	3.0E-02	2.5E-02
1.6E-01	1.6E-01	1.6E-01	1.6E-01	1.6E-01	1.3E-01	1.0E-01	6.3E-02	5.4E-02	4.5E-02
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-165: Hourly GWP Emissions from Microturbine (AC/EC) in a Typical Day in May (ELF).

Perfluoropen	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobut	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohex	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocycl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroetha	2.1E-10	2.0E-10	1.9E-10	1.8E-10	2.3E-10	6.0E-10	8.5E-10	8.5E-10	8.5E-10
Perfluoromet	1.7E-09	1.6E-09	1.5E-09	1.4E-09	1.8E-09	4.7E-09	6.8E-09	6.8E-09	6.8E-09
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.1E-04	1.0E-04	9.8E-05	9.3E-05	1.2E-04	3.1E-04	4.4E-04	4.4E-04	4.4E-04
CH4	2.0E-01	1.8E-01	1.7E-01	1.7E-01	2.1E-01	5.5E-01	7.8E-01	7.8E-01	7.8E-01
CO2	5.1E+01	4.8E+01	4.5E+01	4.3E+01	5.4E+01	1.4E+02	2.0E+02	2.0E+02	2.0E+02
CO2 eq.	5.5E+01	5.2E+01	4.9E+01	4.7E+01	5.9E+01	1.5E+02	2.2E+02	2.2E+02	2.2E+02
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
8.5E-10	8.5E-10	8.5E-10	8.5E-10	8.5E-10	8.5E-10	7.0E-10	5.5E-10	3.4E-10	2.9E-10	2.5E-10
6.8E-09	6.8E-09	6.8E-09	6.8E-09	6.8E-09	6.8E-09	5.6E-09	4.4E-09	2.7E-09	2.3E-09	2.0E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	4.4E-04	3.6E-04	2.8E-04	1.8E-04	1.5E-04	1.3E-04
7.8E-01	7.8E-01	7.8E-01	7.8E-01	7.8E-01	7.8E-01	6.4E-01	5.0E-01	3.2E-01	2.7E-01	2.3E-01
2.0E+02	2.0E+02	2.0E+02	2.0E+02	2.0E+02	2.0E+02	1.7E+02	1.3E+02	8.2E+01	7.0E+01	5.9E+01
2.2E+02	2.2E+02	2.2E+02	2.2E+02	2.2E+02	2.2E+02	1.8E+02	1.4E+02	8.9E+01	7.5E+01	6.4E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-166: Hourly Primary Energy Consumption from Microturbine (AC/EC) in a Typical Day in May (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.6E+02	2.6E+02	1.2E-01	9.1E-02
Hour 4	2.5E+02	2.5E+02	1.1E-01	8.5E-02
hour 5	2.3E+02	2.3E+02	1.0E-01	8.1E-02
Hour 6	2.2E+02	2.2E+02	9.9E-02	7.7E-02
Hour 7	2.8E+02	2.8E+02	1.2E-01	9.8E-02
Hour 8	7.3E+02	7.3E+02	3.2E-01	2.5E-01
Hour 9	1.1E+03	1.0E+03	4.6E-01	3.6E-01
Hour 10	1.1E+03	1.0E+03	4.6E-01	3.6E-01
Hour 11	1.1E+03	1.0E+03	4.6E-01	3.6E-01
Hour 12	1.1E+03	1.0E+03	4.6E-01	3.6E-01
Hour 13	1.1E+03	1.0E+03	4.6E-01	3.6E-01
Hour 14	1.1E+03	1.0E+03	4.6E-01	3.6E-01
Hour 15	1.1E+03	1.0E+03	4.6E-01	3.6E-01
Hour 16	1.1E+03	1.0E+03	4.6E-01	3.6E-01
Hour 17	1.1E+03	1.0E+03	4.6E-01	3.6E-01
Hour 18	8.6E+02	8.6E+02	3.8E-01	3.0E-01
Hour 19	6.8E+02	6.8E+02	3.0E-01	2.3E-01
Hour 20	4.2E+02	4.2E+02	1.9E-01	1.5E-01
Hour 21	3.6E+02	3.6E+02	1.6E-01	1.2E-01
Hour 22	3.0E+02	3.0E+02	1.3E-01	1.1E-01

Table H-167: Hourly Air Emissions from 3-MW ICE (EC) in a Typical Day in May (ELF).

Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	5.2E-05	4.9E-05	4.6E-05	4.4E-05	5.6E-05	1.7E-04	2.5E-04	2.5E-04	2.7E-04	2.7E-04
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	1.5E-04	1.4E-04	1.3E-04	1.3E-04	1.6E-04	4.8E-04	7.1E-04	7.3E-04	7.6E-04	7.8E-04
TOC	4.2E-04	3.9E-04	3.8E-04	3.6E-04	4.5E-04	1.4E-03	2.0E-03	2.1E-03	2.2E-03	2.2E-03
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	1.0E-01	9.8E-02	9.3E-02	8.8E-02	1.1E-01	3.3E-01	5.0E-01	5.1E-01	5.3E-01	5.5E-01
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehy	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	8.3E-09	7.8E-09	7.5E-09	7.1E-09	9.0E-09	2.7E-08	4.1E-08	4.2E-08	4.4E-08	4.6E-08
H2S	1.8E-07	1.7E-07	1.6E-07	1.5E-07	1.9E-07	5.8E-07	8.7E-07	8.9E-07	9.3E-07	9.6E-07
NMVOC	3.5E-03	3.2E-03	3.1E-03	2.9E-03	3.7E-03	1.1E-02	1.7E-02	1.7E-02	1.8E-02	1.8E-02
CO	2.5E-01	2.4E-01	2.3E-01	2.1E-01	2.7E-01	8.1E-01	1.2E+00	1.2E+00	1.3E+00	1.3E+00
Particulates	3.1E-03	2.9E-03	2.7E-03	2.6E-03	3.3E-03	9.9E-03	1.5E-02	1.5E-02	1.6E-02	1.6E-02
HF	9.7E-06	9.2E-06	8.7E-06	8.3E-06	1.0E-05	3.1E-05	4.7E-05	4.8E-05	5.0E-05	5.2E-05
HCl	9.6E-05	9.0E-05	8.6E-05	8.1E-05	1.0E-04	3.1E-04	4.6E-04	4.7E-04	4.9E-04	5.1E-04
NOx	3.7E-02	3.4E-02	3.3E-02	3.1E-02	3.9E-02	1.2E-01	1.8E-01	1.8E-01	1.9E-01	1.9E-01
SO2	2.9E-03	2.7E-03	2.6E-03	2.5E-03	3.1E-03	9.3E-03	1.4E-02	1.4E-02	1.5E-02	1.5E-02
SO2 eq.	2.8E-02	2.7E-02	2.5E-02	2.4E-02	3.1E-02	9.1E-02	1.4E-01	1.4E-01	1.5E-01	1.5E-01
TOPP eq.	7.8E-02	7.3E-02	7.0E-02	6.6E-02	8.4E-02	2.5E-01	3.8E-01	3.8E-01	4.0E-01	4.1E-01
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.7E-04	2.7E-04	2.7E-04	2.8E-04	2.8E-04	2.4E-04	1.9E-04	1.2E-04	8.6E-05	6.6E-05
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
7.7E-04	7.7E-04	7.7E-04	8.0E-04	8.1E-04	6.9E-04	5.5E-04	3.4E-04	2.5E-04	1.9E-04
2.2E-03	2.2E-03	2.2E-03	2.3E-03	2.3E-03	2.0E-03	1.5E-03	9.7E-04	7.0E-04	5.4E-04
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.4E-01	5.4E-01	5.4E-01	5.6E-01	5.7E-01	4.9E-01	3.8E-01	2.4E-01	1.7E-01	1.3E-01
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.5E-08	4.5E-08	4.5E-08	4.7E-08	4.8E-08	4.1E-08	3.2E-08	2.0E-08	1.4E-08	1.1E-08
9.5E-07	9.4E-07	9.4E-07	9.8E-07	9.9E-07	8.5E-07	6.7E-07	4.2E-07	3.0E-07	2.3E-07
1.8E-02	1.8E-02	1.8E-02	1.9E-02	1.9E-02	1.6E-02	1.3E-02	8.0E-03	5.7E-03	4.4E-03
1.3E+00	1.3E+00	1.3E+00	1.4E+00	1.4E+00	1.2E+00	9.3E-01	5.8E-01	4.2E-01	3.2E-01
1.6E-02	1.6E-02	1.6E-02	1.7E-02	1.7E-02	1.4E-02	1.1E-02	7.1E-03	5.1E-03	3.9E-03
5.1E-05	5.1E-05	5.0E-05	5.3E-05	5.3E-05	4.6E-05	3.6E-05	2.3E-05	1.6E-05	1.3E-05
5.0E-04	5.0E-04	4.9E-04	5.2E-04	5.2E-04	4.5E-04	3.5E-04	2.2E-04	1.6E-04	1.2E-04
1.9E-01	1.9E-01	1.9E-01	2.0E-01	2.0E-01	1.7E-01	1.3E-01	8.4E-02	6.1E-02	4.7E-02
1.5E-02	1.5E-02	1.5E-02	1.6E-02	1.6E-02	1.4E-02	1.1E-02	6.7E-03	4.8E-03	3.7E-03
1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.6E-01	1.3E-01	1.0E-01	6.6E-02	4.7E-02	3.6E-02
4.1E-01	4.1E-01	4.0E-01	4.2E-01	4.3E-01	3.7E-01	2.9E-01	1.8E-01	1.3E-01	1.0E-01
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-168: Hourly GWP Emissions from 3-MW ICE (EC) in a Typical Day in May (ELF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
CO2 eq.	3.5E+01	3.3E+01	3.1E+01	2.9E+01	3.7E+01	1.1E+02	1.7E+02	1.7E+02	1.8E+02
CO2	3.1E+01	2.9E+01	2.8E+01	2.6E+01	3.3E+01	9.9E+01	1.5E+02	1.5E+02	1.6E+02
CH4	1.6E-01	1.5E-01	1.5E-01	1.4E-01	1.8E-01	5.3E-01	7.9E-01	8.1E-01	8.5E-01
N2O	1.1E-03	9.9E-04	9.4E-04	9.0E-04	1.1E-03	3.4E-03	5.1E-03	5.2E-03	5.4E-03
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoromethan	1.3E-09	1.2E-09	1.2E-09	1.1E-09	1.4E-09	4.3E-09	6.4E-09	6.6E-09	6.9E-09
Perfluoroethane	1.6E-10	1.5E-10	1.5E-10	1.4E-10	1.8E-10	5.4E-10	8.1E-10	8.2E-10	8.7E-10
Perfluorocyclobu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
9.0E-10	8.8E-10	8.8E-10	8.7E-10	9.1E-10	9.3E-10	8.0E-10	6.3E-10	3.9E-10	2.8E-10	2.1E-10
7.1E-09	7.0E-09	7.0E-09	6.9E-09	7.3E-09	7.4E-09	6.4E-09	5.0E-09	3.1E-09	2.2E-09	1.7E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.6E-03	5.5E-03	5.5E-03	5.4E-03	5.7E-03	5.8E-03	4.9E-03	3.9E-03	2.4E-03	1.7E-03	1.3E-03
8.7E-01	8.6E-01	8.6E-01	8.5E-01	8.9E-01	9.0E-01	7.7E-01	6.1E-01	3.8E-01	2.7E-01	2.1E-01
1.6E+02	1.6E+02	1.6E+02	1.6E+02	1.7E+02	1.7E+02	1.4E+02	1.1E+02	7.1E+01	5.1E+01	3.9E+01
1.8E+02	1.8E+02	1.8E+02	1.8E+02	1.9E+02	1.9E+02	1.6E+02	1.3E+02	8.0E+01	5.8E+01	4.4E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-169: Hourly Primary Energy Consumption from 3-MW ICE (EC) in a Typical Day in May (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	1.88E+02	1.88E+02	8.35E-02	7.34E-02
Hour 4	1.77E+02	1.77E+02	7.85E-02	6.90E-02
Hour 5	1.68E+02	1.68E+02	7.48E-02	6.57E-02
Hour 6	1.60E+02	1.60E+02	7.10E-02	6.24E-02
Hour 7	2.02E+02	2.02E+02	8.97E-02	7.88E-02
Hour 8	6.05E+02	6.05E+02	2.69E-01	2.40E-01
Hour 9	9.05E+02	9.04E+02	4.02E-01	3.61E-01
Hour 10	9.21E+02	9.21E+02	4.10E-01	3.68E-01
Hour 11	9.66E+02	9.65E+02	4.30E-01	3.88E-01
Hour 12	9.94E+02	9.93E+02	4.42E-01	4.00E-01
Hour 13	9.82E+02	9.81E+02	4.37E-01	3.95E-01
Hour 14	9.77E+02	9.76E+02	4.34E-01	3.92E-01
Hour 15	9.71E+02	9.70E+02	4.32E-01	3.90E-01
Hour 16	1.01E+03	1.01E+03	4.50E-01	4.08E-01
Hour 17	1.03E+03	1.03E+03	4.58E-01	4.16E-01
Hour 18	8.80E+02	8.79E+02	3.91E-01	3.57E-01
Hour 19	6.92E+02	6.92E+02	3.08E-01	2.80E-01
Hour 20	4.34E+02	4.34E+02	1.93E-01	1.76E-01
Hour 21	3.13E+02	3.13E+02	1.39E-01	1.25E-01
Hour 22	2.41E+02	2.41E+02	1.07E-01	9.51E-02

Table H-170: Hourly Air Emissions from 3-MW ICE (AC/EC) in a Typical Day in May (ELF).

Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	5.2E-05	4.9E-05	4.6E-05	4.4E-05	5.6E-05	1.5E-04	2.2E-04	2.2E-04	2.3E-04
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	1.5E-04	1.4E-04	1.3E-04	1.3E-04	1.6E-04	4.2E-04	6.2E-04	6.4E-04	6.7E-04
TOC	4.2E-04	3.9E-04	3.8E-04	3.6E-04	4.5E-04	1.2E-03	1.8E-03	1.8E-03	1.9E-03
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	1.0E-01	9.8E-02	9.3E-02	8.8E-02	1.1E-01	2.9E-01	4.3E-01	4.4E-01	4.7E-01
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehyd	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	8.3E-09	7.8E-09	7.5E-09	7.1E-09	9.0E-09	2.3E-08	3.5E-08	3.6E-08	3.7E-08
H2S	1.8E-07	1.7E-07	1.6E-07	1.5E-07	1.9E-07	5.1E-07	7.6E-07	7.8E-07	8.2E-07
NMVOC	3.5E-03	3.2E-03	3.1E-03	2.9E-03	3.7E-03	9.7E-03	1.4E-02	1.5E-02	1.6E-02
CO	2.5E-01	2.4E-01	2.3E-01	2.1E-01	2.7E-01	7.1E-01	1.1E+00	1.1E+00	1.1E+00
Particulates	3.1E-03	2.9E-03	2.7E-03	2.6E-03	3.3E-03	8.6E-03	1.3E-02	1.3E-02	1.4E-02
HF	9.7E-06	9.2E-06	8.7E-06	8.3E-06	1.0E-05	2.7E-05	4.1E-05	4.2E-05	4.4E-05
HCl	9.6E-05	9.0E-05	8.6E-05	8.1E-05	1.0E-04	2.7E-04	4.0E-04	4.1E-04	4.3E-04
NOx	3.7E-02	3.4E-02	3.3E-02	3.1E-02	3.9E-02	1.0E-01	1.5E-01	1.6E-01	1.6E-01
SO2	2.9E-03	2.7E-03	2.6E-03	2.5E-03	3.1E-03	8.1E-03	1.2E-02	1.2E-02	1.3E-02
SO2	2.8E-02	2.7E-02	2.5E-02	2.4E-02	3.1E-02	8.0E-02	1.2E-01	1.2E-01	1.3E-01
TOPP eq.	7.8E-02	7.3E-02	7.0E-02	6.6E-02	8.4E-02	2.2E-01	3.3E-01	3.3E-01	3.5E-01
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.4E-04	2.4E-04	2.4E-04	2.4E-04	2.5E-04	2.5E-04	2.2E-04	1.7E-04	1.1E-04	7.5E-05	6.0E-05
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
6.9E-04	6.8E-04	6.8E-04	6.7E-04	7.0E-04	7.2E-04	6.2E-04	4.8E-04	3.0E-04	2.1E-04	1.7E-04
2.0E-03	1.9E-03	1.9E-03	1.9E-03	2.0E-03	2.0E-03	1.7E-03	1.4E-03	8.6E-04	6.1E-04	4.9E-04
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.8E-01	4.8E-01	4.7E-01	4.7E-01	4.9E-01	5.0E-01	4.3E-01	3.4E-01	2.1E-01	1.5E-01	1.2E-01
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
3.9E-08	3.8E-08	3.8E-08	3.8E-08	4.0E-08	4.0E-08	3.5E-08	2.7E-08	1.7E-08	1.2E-08	9.7E-09
8.4E-07	8.3E-07	8.3E-07	8.2E-07	8.6E-07	8.8E-07	7.5E-07	5.9E-07	3.7E-07	2.6E-07	2.1E-07
1.6E-02	1.6E-02	1.6E-02	1.6E-02	1.6E-02	1.7E-02	1.4E-02	1.1E-02	7.1E-03	5.0E-03	4.0E-03
1.2E+00	1.2E+00	1.2E+00	1.1E+00	1.2E+00	1.2E+00	1.0E+00	8.2E-01	5.2E-01	3.7E-01	2.9E-01
1.4E-02	1.4E-02	1.4E-02	1.4E-02	1.5E-02	1.5E-02	1.3E-02	1.0E-02	6.3E-03	4.4E-03	3.6E-03
4.5E-05	4.5E-05	4.5E-05	4.4E-05	4.6E-05	4.7E-05	4.0E-05	3.2E-05	2.0E-05	1.4E-05	1.1E-05
4.5E-04	4.4E-04	4.4E-04	4.3E-04	4.5E-04	4.6E-04	4.0E-04	3.1E-04	2.0E-04	1.4E-04	1.1E-04
1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.8E-01	1.5E-01	1.2E-01	7.5E-02	5.3E-02	4.3E-02
1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.4E-02	1.4E-02	1.2E-02	9.4E-03	5.9E-03	4.2E-03	3.4E-03
1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.4E-01	1.2E-01	9.2E-02	5.8E-02	4.1E-02	3.3E-02
3.6E-01	3.6E-01	3.6E-01	3.5E-01	3.7E-01	3.8E-01	3.2E-01	2.5E-01	1.6E-01	1.1E-01	9.1E-02
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-171: Hourly GWP Emissions from 3-MW ICE (AC/EC) in a Typical Day in May (ELF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
CO2 Equivalent	3.5E+01	3.3E+01	3.1E+01	2.9E+01	3.7E+01	9.7E+01	1.5E+02	1.5E+02	1.6E+02
CO2	3.1E+01	2.9E+01	2.8E+01	2.6E+01	3.3E+01	8.7E+01	1.3E+02	1.3E+02	1.4E+02
CH4	1.6E-01	1.5E-01	1.5E-01	1.4E-01	1.8E-01	4.6E-01	6.9E-01	7.1E-01	7.4E-01
N2O	1.1E-03	9.9E-04	9.4E-04	9.0E-04	1.1E-03	3.0E-03	4.4E-03	4.5E-03	4.7E-03
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoromethan	1.3E-09	1.2E-09	1.2E-09	1.1E-09	1.4E-09	3.7E-09	5.5E-09	5.6E-09	5.9E-09
Perfluoroethane	1.6E-10	1.5E-10	1.5E-10	1.4E-10	1.8E-10	4.6E-10	6.9E-10	7.0E-10	7.4E-10
Perfluorocyclobu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
7.6E-10	7.5E-10	7.5E-10	7.4E-10	7.8E-10	7.9E-10	6.8E-10	5.3E-10	3.4E-10	2.4E-10	1.9E-10
6.1E-09	6.0E-09	6.0E-09	5.9E-09	6.2E-09	6.3E-09	5.4E-09	4.2E-09	2.7E-09	1.9E-09	1.5E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.9E-03	4.8E-03	4.8E-03	4.8E-03	5.0E-03	5.1E-03	4.4E-03	3.4E-03	2.2E-03	1.5E-03	1.2E-03
7.7E-01	7.5E-01	7.5E-01	7.5E-01	7.8E-01	8.0E-01	6.8E-01	5.4E-01	3.4E-01	2.4E-01	1.9E-01
1.4E+02	1.4E+02	1.4E+02	1.4E+02	1.5E+02	1.5E+02	1.3E+02	1.0E+02	6.3E+01	4.5E+01	3.6E+01
1.6E+02	1.6E+02	1.6E+02	1.6E+02	1.6E+02	1.7E+02	1.4E+02	1.1E+02	7.1E+01	5.0E+01	4.0E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-172: Hourly Primary Energy Consumption from 3-MW ICE (AC/EC) in a Typical Day in May (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	1.9E+02	1.9E+02	8.3E-02	7.3E-02
Hour 4	1.8E+02	1.8E+02	7.8E-02	6.9E-02
Hour 5	1.7E+02	1.7E+02	7.5E-02	6.6E-02
Hour 6	1.6E+02	1.6E+02	7.1E-02	6.2E-02
Hour 7	2.0E+02	2.0E+02	9.0E-02	7.9E-02
Hour 8	5.3E+02	5.3E+02	2.3E-01	2.1E-01
Hour 9	7.9E+02	7.9E+02	3.5E-01	3.1E-01
Hour 10	8.1E+02	8.1E+02	3.6E-01	3.1E-01
Hour 11	8.5E+02	8.5E+02	3.8E-01	3.3E-01
Hour 12	8.8E+02	8.8E+02	3.9E-01	3.4E-01
Hour 13	8.6E+02	8.6E+02	3.8E-01	3.4E-01
Hour 14	8.6E+02	8.6E+02	3.8E-01	3.4E-01
Hour 15	8.5E+02	8.5E+02	3.8E-01	3.3E-01
Hour 16	8.9E+02	8.9E+02	4.0E-01	3.5E-01
Hour 17	9.1E+02	9.1E+02	4.0E-01	3.6E-01
Hour 18	7.8E+02	7.8E+02	3.5E-01	3.0E-01
Hour 19	6.1E+02	6.1E+02	2.7E-01	2.4E-01
Hour 20	3.8E+02	3.8E+02	1.7E-01	1.5E-01
Hour 21	2.7E+02	2.7E+02	1.2E-01	1.1E-01
Hour 22	2.2E+02	2.2E+02	9.7E-02	8.5E-02

Table H-173: Hourly Air Emissions from 143-kW ICE (EC) in a Typical Day in May (ELF).

Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
TOPP eq.	1.0E-01	9.8E-02	9.3E-02	8.8E-02	1.1E-01	3.3E-01	5.0E-01	5.1E-01	5.3E-01
SO2	3.8E-02	3.6E-02	3.4E-02	3.2E-02	4.1E-02	1.2E-01	1.8E-01	1.9E-01	1.9E-01
SO2	3.8E-03	3.6E-03	3.4E-03	3.2E-03	4.1E-03	1.2E-02	1.8E-02	1.9E-02	2.0E-02
NOx	4.9E-02	4.6E-02	4.3E-02	4.1E-02	5.2E-02	1.6E-01	2.3E-01	2.4E-01	2.5E-01
HCl	1.3E-04	1.2E-04	1.1E-04	1.1E-04	1.4E-04	4.1E-04	6.1E-04	6.2E-04	6.5E-04
HF	1.3E-05	1.2E-05	1.2E-05	1.1E-05	1.4E-05	4.2E-05	6.2E-05	6.4E-05	6.7E-05
Particulates	4.1E-03	3.8E-03	3.6E-03	3.5E-03	4.4E-03	1.3E-02	2.0E-02	2.0E-02	2.1E-02
CO	3.4E-01	3.2E-01	3.0E-01	2.9E-01	3.6E-01	1.1E+00	1.6E+00	1.6E+00	1.7E+00
NMVOC	4.6E-03	4.3E-03	4.1E-03	3.9E-03	4.9E-03	1.5E-02	2.2E-02	2.2E-02	2.4E-02
H2S	2.4E-07	2.3E-07	2.2E-07	2.1E-07	2.6E-07	7.8E-07	1.2E-06	1.2E-06	1.2E-06
NH3	1.0E-08	9.7E-09	9.3E-09	8.8E-09	1.1E-08	3.4E-08	5.1E-08	5.2E-08	5.5E-08
Acetaldehyd	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	1.0E-01	9.8E-02	9.3E-02	8.8E-02	1.1E-01	3.3E-01	5.0E-01	5.1E-01	5.3E-01
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TOC	4.2E-04	3.9E-04	3.8E-04	3.6E-04	4.5E-04	1.4E-03	2.0E-03	2.1E-03	2.2E-03
Toluene	1.5E-04	1.4E-04	1.3E-04	1.3E-04	1.6E-04	4.8E-04	7.1E-04	7.3E-04	7.6E-04
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	5.2E-05	4.9E-05	4.6E-05	4.4E-05	5.6E-05	1.7E-04	2.5E-04	2.5E-04	2.7E-04
Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.7E-04	2.7E-04	2.7E-04	2.7E-04	2.8E-04	2.8E-04	2.4E-04	1.9E-04	1.2E-04	8.6E-05	6.6E-05
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
7.8E-04	7.7E-04	7.7E-04	7.7E-04	8.0E-04	8.1E-04	6.9E-04	5.5E-04	3.4E-04	2.5E-04	1.9E-04
2.2E-03	2.2E-03	2.2E-03	2.2E-03	2.3E-03	2.3E-03	2.0E-03	1.5E-03	9.7E-04	7.0E-04	5.4E-04
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.5E-01	5.4E-01	5.4E-01	5.4E-01	5.6E-01	5.7E-01	4.9E-01	3.8E-01	2.4E-01	1.7E-01	1.3E-01
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.6E-08	5.6E-08	5.5E-08	5.5E-08	5.8E-08	5.9E-08	5.0E-08	4.0E-08	2.5E-08	1.8E-08	1.3E-08
1.3E-06	1.3E-06	1.3E-06	1.2E-06	1.3E-06	1.3E-06	1.1E-06	8.9E-07	5.6E-07	4.0E-07	3.1E-07
2.4E-02	2.4E-02	2.4E-02	2.4E-02	2.5E-02	2.5E-02	2.1E-02	1.7E-02	1.1E-02	7.6E-03	5.9E-03
1.8E+00	1.8E+00	1.7E+00	1.7E+00	1.8E+00	1.8E+00	1.6E+00	1.2E+00	7.8E-01	5.6E-01	4.3E-01
2.1E-02	2.1E-02	2.1E-02	2.1E-02	2.2E-02	2.2E-02	1.9E-02	1.5E-02	9.4E-03	6.8E-03	5.2E-03
6.9E-05	6.8E-05	6.7E-05	6.7E-05	7.0E-05	7.1E-05	6.1E-05	4.8E-05	3.0E-05	2.2E-05	1.7E-05
6.7E-04	6.7E-04	6.6E-04	6.6E-04	6.9E-04	7.0E-04	6.0E-04	4.7E-04	2.9E-04	2.1E-04	1.6E-04
2.6E-01	2.5E-01	2.5E-01	2.5E-01	2.6E-01	2.7E-01	2.3E-01	1.8E-01	1.1E-01	8.1E-02	6.2E-02
2.0E-02	2.0E-02	2.0E-02	2.0E-02	2.1E-02	2.1E-02	1.8E-02	1.4E-02	8.8E-03	6.4E-03	4.9E-03
2.0E-01	2.0E-01	2.0E-01	2.0E-01	2.0E-01	2.1E-01	1.8E-01	1.4E-01	8.7E-02	6.3E-02	4.8E-02
5.5E-01	5.4E-01	5.4E-01	5.4E-01	5.6E-01	5.7E-01	4.9E-01	3.8E-01	2.4E-01	1.7E-01	1.3E-01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-174: Hourly GWP Emissions from 143-kW ICE (EC) in a Typical Day in May (ELF).

Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclobu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethane	2.1E-10	1.9E-10	1.8E-10	1.7E-10	2.2E-10	6.7E-10	1.0E-09	1.0E-09	1.1E-09
Perfluoromethan	1.6E-09	1.5E-09	1.5E-09	1.4E-09	1.8E-09	5.3E-09	8.0E-09	8.2E-09	8.6E-09
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.4E-03	1.3E-03	1.3E-03	1.2E-03	1.5E-03	4.5E-03	6.7E-03	6.9E-03	7.2E-03
CH4	2.2E-01	2.1E-01	2.0E-01	1.9E-01	2.4E-01	7.0E-01	1.1E+00	1.1E+00	1.1E+00
CO2	4.1E+01	3.9E+01	3.7E+01	3.5E+01	4.4E+01	1.3E+02	2.0E+02	2.0E+02	2.1E+02
CO2 Equivalent	4.6E+01	4.3E+01	4.1E+01	3.9E+01	4.9E+01	1.5E+02	2.2E+02	2.3E+02	2.4E+02
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
1.1E-09	1.1E-09	1.1E-09	1.1E-09	1.1E-09	1.2E-09	9.9E-10	7.8E-10	4.9E-10	3.5E-10	2.7E-10
8.9E-09	8.7E-09	8.7E-09	8.6E-09	9.0E-09	9.2E-09	7.9E-09	6.2E-09	3.9E-09	2.8E-09	2.1E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
7.4E-03	7.3E-03	7.3E-03	7.2E-03	7.5E-03	7.7E-03	6.6E-03	5.2E-03	3.2E-03	2.3E-03	1.8E-03
1.2E+00	1.1E+00	1.1E+00	1.1E+00	1.2E+00	1.2E+00	1.0E+00	8.1E-01	5.1E-01	3.6E-01	2.8E-01
2.2E+02	2.1E+02	2.1E+02	2.1E+02	2.2E+02	2.2E+02	1.9E+02	1.5E+02	9.5E+01	6.8E+01	5.3E+01
2.4E+02	2.4E+02	2.4E+02	2.4E+02	2.5E+02	2.5E+02	2.2E+02	1.7E+02	1.1E+02	7.7E+01	5.9E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-175: Hourly Primary Energy Consumption from 143-kW ICE (EC) in a Typical Day in May (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.5E+02	2.5E+02	1.1E-01	8.8E-02
Hour 4	2.4E+02	2.3E+02	1.0E-01	8.3E-02
hour 5	2.2E+02	2.2E+02	9.9E-02	7.9E-02
Hour 6	2.1E+02	2.1E+02	9.4E-02	7.5E-02
Hour 7	2.7E+02	2.7E+02	1.2E-01	9.5E-02
Hour 8	8.1E+02	8.0E+02	3.6E-01	2.9E-01
Hour 9	1.2E+03	1.2E+03	5.3E-01	4.3E-01
Hour 10	1.2E+03	1.2E+03	5.4E-01	4.4E-01
Hour 11	1.3E+03	1.3E+03	5.7E-01	4.6E-01
Hour 12	1.3E+03	1.3E+03	5.9E-01	4.8E-01
Hour 13	1.3E+03	1.3E+03	5.8E-01	4.7E-01
Hour 14	1.3E+03	1.3E+03	5.8E-01	4.7E-01
Hour 15	1.3E+03	1.3E+03	5.7E-01	4.7E-01
Hour 16	1.3E+03	1.3E+03	6.0E-01	4.9E-01
Hour 17	1.4E+03	1.4E+03	6.1E-01	5.0E-01
Hour 18	1.2E+03	1.2E+03	5.2E-01	4.3E-01
Hour 19	9.2E+02	9.2E+02	4.1E-01	3.4E-01
Hour 20	5.8E+02	5.8E+02	2.6E-01	2.1E-01
Hour 21	4.2E+02	4.2E+02	1.8E-01	1.5E-01
Hour 22	3.2E+02	3.2E+02	1.4E-01	1.1E-01

Table H-176: Hourly Air Emissions from 143-kW ICE (AC/EC) in a Typical Day in May (ELF).

Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
TOPP eq.	1.0E-01	9.8E-02	9.3E-02	8.8E-02	1.1E-01	2.9E-01	4.2E-01	4.2E-01	4.3E-01
SO2	3.8E-02	3.6E-02	3.4E-02	3.2E-02	4.1E-02	1.1E-01	1.5E-01	1.5E-01	1.6E-01
SO2	3.8E-03	3.6E-03	3.4E-03	3.2E-03	4.1E-03	1.1E-02	1.5E-02	1.5E-02	1.6E-02
NOx	4.9E-02	4.6E-02	4.3E-02	4.1E-02	5.2E-02	1.4E-01	2.0E-01	2.0E-01	2.0E-01
HCl	1.3E-04	1.2E-04	1.1E-04	1.1E-04	1.4E-04	3.6E-04	5.1E-04	5.1E-04	5.2E-04
HF	1.3E-05	1.2E-05	1.2E-05	1.1E-05	1.4E-05	3.6E-05	5.2E-05	5.2E-05	5.3E-05
Particulates	4.1E-03	3.8E-03	3.6E-03	3.5E-03	4.4E-03	1.1E-02	1.6E-02	1.6E-02	1.7E-02
CO	3.4E-01	3.2E-01	3.0E-01	2.9E-01	3.6E-01	9.4E-01	1.3E+00	1.3E+00	1.4E+00
NMVOC	4.6E-03	4.3E-03	4.1E-03	3.9E-03	4.9E-03	1.3E-02	1.8E-02	1.8E-02	1.9E-02
H2S	2.4E-07	2.3E-07	2.2E-07	2.1E-07	2.6E-07	6.8E-07	9.7E-07	9.7E-07	9.9E-07
NH3	1.0E-08	9.7E-09	9.3E-09	8.8E-09	1.1E-08	2.9E-08	4.2E-08	4.2E-08	4.2E-08
Acetaldehyde	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	1.0E-01	9.8E-02	9.3E-02	8.8E-02	1.1E-01	2.9E-01	4.2E-01	4.2E-01	4.3E-01
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenum	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TOC	4.2E-04	3.9E-04	3.8E-04	3.6E-04	4.5E-04	1.2E-03	1.7E-03	1.7E-03	1.7E-03
Toluene	1.5E-04	1.4E-04	1.3E-04	1.3E-04	1.6E-04	4.2E-04	6.0E-04	6.0E-04	6.1E-04
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	5.2E-05	4.9E-05	4.6E-05	4.4E-05	5.6E-05	1.5E-04	2.1E-04	2.1E-04	2.1E-04
Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.2E-04	2.2E-04	2.2E-04	2.1E-04	2.3E-04	2.3E-04	2.0E-04	1.5E-04	9.8E-05	7.1E-05	6.0E-05
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
6.3E-04	6.2E-04	6.2E-04	6.1E-04	6.4E-04	6.6E-04	5.6E-04	4.4E-04	2.8E-04	2.0E-04	1.7E-04
1.8E-03	1.8E-03	1.7E-03	1.7E-03	1.8E-03	1.9E-03	1.6E-03	1.3E-03	7.9E-04	5.8E-04	4.9E-04
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.4E-01	4.3E-01	4.3E-01	4.3E-01	4.5E-01	4.6E-01	3.9E-01	3.1E-01	2.0E-01	1.4E-01	1.2E-01
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.4E-08	4.3E-08	4.3E-08	4.3E-08	4.5E-08	4.6E-08	3.9E-08	3.1E-08	1.9E-08	1.4E-08	1.2E-08
1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.1E-06	9.1E-07	7.2E-07	4.5E-07	3.3E-07	2.8E-07
1.9E-02	1.9E-02	1.9E-02	1.9E-02	2.0E-02	2.0E-02	1.7E-02	1.4E-02	8.6E-03	6.3E-03	5.3E-03
1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.5E+00	1.5E+00	1.3E+00	1.0E+00	6.3E-01	4.6E-01	3.9E-01
1.7E-02	1.7E-02	1.7E-02	1.7E-02	1.8E-02	1.8E-02	1.5E-02	1.2E-02	7.6E-03	5.6E-03	4.7E-03
5.5E-05	5.4E-05	5.4E-05	5.4E-05	5.6E-05	5.7E-05	4.9E-05	3.9E-05	2.4E-05	1.8E-05	1.5E-05
5.4E-04	5.3E-04	5.3E-04	5.3E-04	5.5E-04	5.6E-04	4.8E-04	3.8E-04	2.4E-04	1.7E-04	1.5E-04
2.1E-01	2.0E-01	2.0E-01	2.0E-01	2.1E-01	2.1E-01	1.8E-01	1.5E-01	9.1E-02	6.7E-02	5.7E-02
1.6E-02	1.6E-02	1.6E-02	1.6E-02	1.7E-02	1.7E-02	1.4E-02	1.1E-02	7.2E-03	5.2E-03	4.4E-03
1.6E-01	1.6E-01	1.6E-01	1.6E-01	1.6E-01	1.7E-01	1.4E-01	1.1E-01	7.1E-02	5.2E-02	4.4E-02
4.4E-01	4.3E-01	4.3E-01	4.3E-01	4.5E-01	4.6E-01	3.9E-01	3.1E-01	2.0E-01	1.4E-01	1.2E-01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-177: Hourly GWP Emissions from 143-kW ICE (AC/EC) in a Typical Day in May (ELF).

Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclobuta	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethane	2.1E-10	1.9E-10	1.8E-10	1.7E-10	2.2E-10	5.8E-10	8.2E-10	8.2E-10	8.4E-10
Perfluoromethane	1.6E-09	1.5E-09	1.5E-09	1.4E-09	1.8E-09	4.6E-09	6.6E-09	6.6E-09	6.7E-09
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.4E-03	1.3E-03	1.3E-03	1.2E-03	1.5E-03	3.9E-03	5.6E-03	5.6E-03	5.7E-03
CH4	2.2E-01	2.1E-01	2.0E-01	1.9E-01	2.4E-01	6.1E-01	8.8E-01	8.8E-01	9.0E-01
CO2	4.1E+01	3.9E+01	3.7E+01	3.5E+01	4.4E+01	1.2E+02	1.6E+02	1.6E+02	1.7E+02
CO2 Equivalent	4.6E+01	4.3E+01	4.1E+01	3.9E+01	4.9E+01	1.3E+02	1.8E+02	1.8E+02	1.9E+02
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
8.7E-10	8.6E-10	8.5E-10	8.5E-10	8.9E-10	9.0E-10	7.8E-10	6.1E-10	3.9E-10	2.8E-10	2.4E-10
6.9E-09	6.8E-09	6.8E-09	6.7E-09	7.1E-09	7.2E-09	6.2E-09	4.9E-09	3.1E-09	2.2E-09	1.9E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.9E-03	5.9E-03	5.8E-03	5.8E-03	6.1E-03	6.2E-03	5.3E-03	4.2E-03	2.6E-03	1.9E-03	1.6E-03
9.3E-01	9.2E-01	9.1E-01	9.1E-01	9.5E-01	9.7E-01	8.3E-01	6.5E-01	4.1E-01	3.0E-01	2.6E-01
1.7E+02	1.7E+02	1.7E+02	1.7E+02	1.8E+02	1.8E+02	1.6E+02	1.2E+02	7.7E+01	5.6E+01	4.8E+01
2.0E+02	1.9E+02	1.9E+02	1.9E+02	2.0E+02	2.0E+02	1.7E+02	1.4E+02	8.7E+01	6.3E+01	5.4E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-178: Hourly Primary Energy Consumption from 143-kW ICE (AC/EC) in a Typical Day in May (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.5E+02	2.5E+02	1.1E-01	8.8E-02
Hour 4	2.4E+02	2.3E+02	1.0E-01	8.3E-02
hour 5	2.2E+02	2.2E+02	9.9E-02	7.9E-02
Hour 6	2.1E+02	2.1E+02	9.4E-02	7.5E-02
Hour 7	2.7E+02	2.7E+02	1.2E-01	9.5E-02
Hour 8	7.0E+02	7.0E+02	3.1E-01	2.5E-01
Hour 9	1.0E+03	1.0E+03	4.4E-01	3.5E-01
Hour 10	1.0E+03	1.0E+03	4.4E-01	3.5E-01
Hour 11	1.0E+03	1.0E+03	4.6E-01	3.6E-01
Hour 12	1.1E+03	1.1E+03	4.7E-01	3.7E-01
Hour 13	1.0E+03	1.0E+03	4.6E-01	3.7E-01
Hour 14	1.0E+03	1.0E+03	4.6E-01	3.7E-01
Hour 15	1.0E+03	1.0E+03	4.6E-01	3.6E-01
Hour 16	1.1E+03	1.1E+03	4.8E-01	3.8E-01
Hour 17	1.1E+03	1.1E+03	4.9E-01	3.9E-01
Hour 18	9.5E+02	9.5E+02	4.2E-01	3.3E-01
Hour 19	7.5E+02	7.5E+02	3.3E-01	2.6E-01
Hour 20	4.7E+02	4.7E+02	2.1E-01	1.7E-01
Hour 21	3.4E+02	3.4E+02	1.5E-01	1.2E-01
Hour 22	2.9E+02	2.9E+02	1.3E-01	1.0E-01

Table H-179: Hourly Air Emissions from SOFC (EC) in a Typical Day in August (ELF).

Option	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
Ozon	1.3E-02	1.2E-02	1.2E-02	1.1E-02	1.4E-02	3.6E-02	5.0E-02	5.3E-02	5.2E-02	5.5E-02
SO2	8.3E-03	8.0E-03	7.7E-03	7.3E-03	9.3E-03	2.4E-02	3.3E-02	3.5E-02	3.4E-02	3.6E-02
SO2	2.9E-03	2.8E-03	2.7E-03	2.6E-03	3.3E-03	8.4E-03	1.2E-02	1.2E-02	1.2E-02	1.3E-02
NOx	7.5E-03	7.3E-03	7.0E-03	6.7E-03	8.4E-03	2.1E-02	3.0E-02	3.2E-02	3.1E-02	3.3E-02
HCl	1.0E-04	9.9E-05	9.5E-05	9.1E-05	1.1E-04	2.9E-04	4.1E-04	4.3E-04	4.3E-04	4.5E-04
HF	1.2E-05	1.1E-05	1.1E-05	1.0E-05	1.3E-05	3.3E-05	4.7E-05	5.0E-05	4.9E-05	5.2E-05
Particulat	6.0E-04	5.8E-04	5.6E-04	5.3E-04	6.8E-04	1.7E-03	2.4E-03	2.6E-03	2.5E-03	2.7E-03
CO	5.9E-03	5.7E-03	5.5E-03	5.2E-03	6.6E-03	1.7E-02	2.3E-02	2.5E-02	2.5E-02	2.6E-02
NMVOC	6.8E-04	6.6E-04	6.3E-04	6.0E-04	7.6E-04	1.9E-03	2.7E-03	2.9E-03	2.8E-03	3.0E-03
H2S	1.9E-07	1.8E-07	1.8E-07	1.7E-07	2.1E-07	5.4E-07	7.5E-07	8.0E-07	7.9E-07	8.3E-07
NH3	8.3E-09	8.1E-09	7.8E-09	7.4E-09	9.4E-09	2.4E-08	3.3E-08	3.6E-08	3.5E-08	3.7E-08
Acetalde	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Berylliu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmiu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromiu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mangane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybde	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadiu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.1E-08	4.2E-08	4.1E-08	4.4E-08	4.4E-08	3.6E-08	2.6E-08	1.8E-08	1.3E-08	1.0E-08
9.0E-07	9.1E-07	8.9E-07	9.5E-07	9.5E-07	7.7E-07	5.7E-07	3.8E-07	2.8E-07	2.3E-07
3.2E-03	3.3E-03	3.2E-03	3.4E-03	3.4E-03	2.8E-03	2.0E-03	1.4E-03	1.0E-03	8.3E-04
2.8E-02	2.9E-02	2.8E-02	3.0E-02	3.0E-02	2.4E-02	1.8E-02	1.2E-02	8.9E-03	7.2E-03
2.9E-03	2.9E-03	2.9E-03	3.1E-03	3.1E-03	2.5E-03	1.8E-03	1.2E-03	9.1E-04	7.4E-04
5.6E-05	5.7E-05	5.5E-05	5.9E-05	5.9E-05	4.8E-05	3.5E-05	2.4E-05	1.8E-05	1.4E-05
4.9E-04	4.9E-04	4.8E-04	5.2E-04	5.1E-04	4.2E-04	3.1E-04	2.1E-04	1.5E-04	1.3E-04
3.6E-02	3.6E-02	3.5E-02	3.8E-02	3.8E-02	3.1E-02	2.3E-02	1.5E-02	1.1E-02	9.2E-03
1.4E-02	1.4E-02	1.4E-02	1.5E-02	1.5E-02	1.2E-02	8.9E-03	6.0E-03	4.4E-03	3.6E-03
3.9E-02	4.0E-02	3.9E-02	4.2E-02	4.2E-02	3.4E-02	2.5E-02	1.7E-02	1.2E-02	1.0E-02
6.0E-02	6.0E-02	5.9E-02	6.3E-02	6.3E-02	5.1E-02	3.8E-02	2.6E-02	1.9E-02	1.5E-02
Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-180: Hourly GWP Emissions from SOFC (EC) in a Typical Day in August (ELF).

Option [kg]	CO_2 Equivalent	CO_2	CH_4	N_2O	HFC-23	HFC-32	HFC-43-10mee	HFC-125	HFC-134	HFC-134a	HFC-152a	HFC-143	HFC-143a	HFC-227	HFC-236	HFC-245	SF_6	Perfluorometha	Perfluoroethane	Perfluorocyclob	Perfluorohexane	Perfluoropropan	Perfluorobutane	Perfluoropentan
Hour 3	4.0E+01	3.7E+01	1.5E-01	8.3E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.7E-07	8.4E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Hour 4	3.9E+01	3.6E+01	1.4E-01	8.0E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.5E-07	8.1E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Hour 5	3.7E+01	3.4E+01	1.4E-01	7.7E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.2E-07	7.8E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Hour 6	3.6E+01	3.3E+01	1.3E-01	7.3E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.9E-07	7.4E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Hour 7	4.5E+01	4.1E+01	1.6E-01	9.2E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.5E-07	9.4E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Hour 8	1.1E+02	1.1E+02	4.2E-01	2.3E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.9E-06	2.4E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Hour 9	1.6E+02	1.5E+02	5.8E-01	3.3E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.7E-06	3.3E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Hour 10	1.7E+02	1.6E+02	6.2E-01	3.5E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.8E-06	3.6E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Hour 11	1.7E+02	1.5E+02	6.1E-01	3.4E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.8E-06	3.5E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
3.7E-07	4.0E-07	4.0E-07	4.0E-07	4.2E-07	4.2E-07	3.4E-07	2.5E-07	1.7E-07	1.3E-07	1.0E-07
2.9E-06	3.2E-06	3.2E-06	3.1E-06	3.4E-06	3.4E-06	2.7E-06	2.0E-06	1.4E-06	1.0E-06	8.1E-07
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
3.6E-04	3.9E-04	4.0E-04	3.9E-04	4.2E-04	4.1E-04	3.4E-04	2.5E-04	1.7E-04	1.2E-04	1.0E-04
6.4E-01	6.9E-01	7.0E-01	6.9E-01	7.4E-01	7.3E-01	6.0E-01	4.4E-01	3.0E-01	2.2E-01	1.8E-01
1.6E+02	1.8E+02	1.8E+02	1.7E+02	1.9E+02	1.9E+02	1.5E+02	1.1E+02	7.5E+01	5.5E+01	4.5E+01
1.8E+02	1.9E+02	1.9E+02	1.9E+02	2.0E+02	2.0E+02	1.6E+02	1.2E+02	8.2E+01	6.0E+01	4.9E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-181: Hourly Primary Energy Consumption from SOFC (EC) in a Typical Day in August (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.0E+02	2.0E+02	9.5E-02	7.2E-02
Hour 4	1.9E+02	1.9E+02	9.2E-02	6.9E-02
Hour 5	1.8E+02	1.8E+02	8.8E-02	6.7E-02
Hour 6	1.7E+02	1.7E+02	8.4E-02	6.3E-02
Hour 7	2.2E+02	2.2E+02	1.1E-01	8.0E-02
Hour 8	5.6E+02	5.6E+02	2.7E-01	2.0E-01
Hour 9	7.8E+02	7.8E+02	3.8E-01	2.8E-01
Hour 10	8.3E+02	8.3E+02	4.0E-01	3.1E-01
Hour 11	8.2E+02	8.1E+02	3.9E-01	3.0E-01
Hour 12	8.6E+02	8.6E+02	4.2E-01	3.2E-01
Hour 13	9.3E+02	9.3E+02	4.5E-01	3.5E-01
Hour 14	9.4E+02	9.4E+02	4.6E-01	3.5E-01
Hour 15	9.2E+02	9.2E+02	4.5E-01	3.4E-01
Hour 16	9.9E+02	9.9E+02	4.8E-01	3.7E-01
Hour 17	9.8E+02	9.8E+02	4.8E-01	3.7E-01
Hour 18	8.0E+02	8.0E+02	3.9E-01	3.0E-01
Hour 19	5.9E+02	5.9E+02	2.9E-01	2.2E-01
Hour 20	4.0E+02	4.0E+02	1.9E-01	1.5E-01
Hour 21	2.9E+02	2.9E+02	1.4E-01	1.1E-01
Hour 22	2.4E+02	2.4E+02	1.2E-01	8.8E-02

Table H-182: Hourly Air Emissions from SOFC (AC/EC) in a Typical Day in August (ELF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
Ozon	1.1E-02	1.1E-02	1.0E-02	1.0E-02	1.3E-02	3.2E-02	4.5E-02	4.7E-02	4.7E-02
SO2	7.5E-03	7.2E-03	6.9E-03	6.6E-03	8.4E-03	2.1E-02	2.9E-02	3.1E-02	3.1E-02
SO2	2.7E-03	2.5E-03	2.4E-03	2.3E-03	3.0E-03	7.5E-03	1.0E-02	1.1E-02	1.1E-02
NOx	6.8E-03	6.5E-03	6.3E-03	6.0E-03	7.6E-03	1.9E-02	2.7E-02	2.8E-02	2.8E-02
HCl	9.3E-05	8.9E-05	8.5E-05	8.2E-05	1.0E-04	2.6E-04	3.6E-04	3.9E-04	3.8E-04
HF	1.1E-05	1.0E-05	9.8E-06	9.4E-06	1.2E-05	3.0E-05	4.2E-05	4.4E-05	4.4E-05
Particulates	5.4E-04	5.2E-04	5.0E-04	4.8E-04	6.1E-04	1.5E-03	2.1E-03	2.3E-03	2.2E-03
CO	5.3E-03	5.1E-03	4.9E-03	4.6E-03	5.9E-03	1.5E-02	2.1E-02	2.2E-02	2.2E-02
NMVOC	6.1E-04	5.9E-04	5.6E-04	5.4E-04	6.9E-04	1.7E-03	2.4E-03	2.6E-03	2.5E-03
H2S	1.7E-07	1.6E-07	1.6E-07	1.5E-07	1.9E-07	4.8E-07	6.7E-07	7.1E-07	7.0E-07
NH3	7.2E-09	7.0E-09	6.7E-09	6.4E-09	8.1E-09	2.1E-08	2.9E-08	3.0E-08	3.0E-08
Acetaldehy	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
3.2E-08	3.4E-08	3.5E-08	3.4E-08	3.6E-08	3.6E-08	2.9E-08	2.2E-08	1.5E-08	1.1E-08	8.8E-09
7.4E-07	8.0E-07	8.1E-07	7.9E-07	8.6E-07	8.5E-07	6.9E-07	5.1E-07	3.4E-07	2.5E-07	2.1E-07
2.7E-03	2.9E-03	2.9E-03	2.9E-03	3.1E-03	3.0E-03	2.5E-03	1.8E-03	1.2E-03	9.1E-04	7.4E-04
2.3E-02	2.5E-02	2.5E-02	2.5E-02	2.6E-02	2.6E-02	2.1E-02	1.6E-02	1.1E-02	7.8E-03	6.4E-03
2.4E-03	2.6E-03	2.6E-03	2.5E-03	2.7E-03	2.7E-03	2.2E-03	1.6E-03	1.1E-03	8.1E-04	6.6E-04
4.6E-05	5.0E-05	5.1E-05	4.9E-05	5.3E-05	5.3E-05	4.3E-05	3.2E-05	2.1E-05	1.6E-05	1.3E-05
4.0E-04	4.4E-04	4.4E-04	4.3E-04	4.6E-04	4.6E-04	3.8E-04	2.8E-04	1.9E-04	1.4E-04	1.1E-04
3.0E-02	3.2E-02	3.2E-02	3.2E-02	3.4E-02	3.4E-02	2.7E-02	2.0E-02	1.4E-02	1.0E-02	8.2E-03
1.2E-02	1.2E-02	1.3E-02	1.2E-02	1.3E-02	1.3E-02	1.1E-02	7.9E-03	5.3E-03	3.9E-03	3.2E-03
3.3E-02	3.5E-02	3.6E-02	3.5E-02	3.7E-02	3.7E-02	3.0E-02	2.2E-02	1.5E-02	1.1E-02	9.0E-03
4.9E-02	5.3E-02	5.4E-02	5.3E-02	5.7E-02	5.6E-02	4.6E-02	3.4E-02	2.3E-02	1.7E-02	1.4E-02
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-183: Hourly GWP Emissions from SOFC (AC/EC) in a Typical Day in August (ELF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
CO2 Equivalent	3.6E+01	3.5E+01	3.3E+01	3.2E+01	4.1E+01	1.0E+02	1.4E+02	1.5E+02	1.5E+02
CO2	3.4E+01	3.2E+01	3.1E+01	3.0E+01	3.7E+01	9.5E+01	1.3E+02	1.4E+02	1.4E+02
CH4	1.3E-01	1.3E-01	1.2E-01	1.2E-01	1.5E-01	3.8E-01	5.2E-01	5.5E-01	5.5E-01
N2O	7.4E-05	7.2E-05	6.9E-05	6.6E-05	8.3E-05	2.1E-04	2.9E-04	3.1E-04	3.1E-04
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoromethane	6.0E-07	5.8E-07	5.6E-07	5.3E-07	6.8E-07	1.7E-06	2.4E-06	2.5E-06	2.5E-06
Perfluoroethane	7.6E-08	7.3E-08	7.0E-08	6.7E-08	8.5E-08	2.2E-07	3.0E-07	3.2E-07	3.1E-07
Perfluorocyclobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
3.3E-07	3.6E-07	3.6E-07	3.5E-07	3.8E-07	3.8E-07	3.1E-07	2.3E-07	1.5E-07	1.1E-07	9.2E-08
2.6E-06	2.8E-06	2.9E-06	2.8E-06	3.0E-06	3.0E-06	2.5E-06	1.8E-06	1.2E-06	9.0E-07	7.3E-07
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
3.2E-04	3.5E-04	3.6E-04	3.5E-04	3.7E-04	3.7E-04	3.0E-04	2.2E-04	1.5E-04	1.1E-04	9.0E-05
5.8E-01	6.2E-01	6.3E-01	6.1E-01	6.6E-01	6.6E-01	5.4E-01	3.9E-01	2.7E-01	2.0E-01	1.6E-01
1.5E+02	1.6E+02	1.6E+02	1.6E+02	1.7E+02	1.7E+02	1.4E+02	1.0E+02	6.7E+01	5.0E+01	4.1E+01
1.6E+02	1.7E+02	1.7E+02	1.7E+02	1.8E+02	1.8E+02	1.5E+02	1.1E+02	7.3E+01	5.4E+01	4.4E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-184: Hourly Primary Energy Consumption from SOFC (AC/EC) in a Typical Day in August (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	1.8E+02	1.8E+02	8.6E-02	6.3E-02
Hour 4	1.7E+02	1.7E+02	8.2E-02	6.0E-02
Hour 5	1.6E+02	1.6E+02	7.9E-02	5.8E-02
Hour 6	1.6E+02	1.6E+02	7.6E-02	5.5E-02
Hour 7	2.0E+02	2.0E+02	9.6E-02	7.0E-02
Hour 8	5.0E+02	5.0E+02	2.4E-01	1.8E-01
Hour 9	7.0E+02	7.0E+02	3.4E-01	2.5E-01
Hour 10	7.4E+02	7.4E+02	3.6E-01	2.6E-01
Hour 11	7.3E+02	7.3E+02	3.5E-01	2.6E-01
Hour 12	7.7E+02	7.7E+02	3.7E-01	2.7E-01
Hour 13	8.3E+02	8.3E+02	4.0E-01	3.0E-01
Hour 14	8.5E+02	8.5E+02	4.1E-01	3.0E-01
Hour 15	8.2E+02	8.2E+02	4.0E-01	2.9E-01
Hour 16	8.9E+02	8.9E+02	4.3E-01	3.1E-01
Hour 17	8.8E+02	8.8E+02	4.3E-01	3.1E-01
Hour 18	7.2E+02	7.2E+02	3.5E-01	2.5E-01
Hour 19	5.3E+02	5.3E+02	2.6E-01	1.9E-01
Hour 20	3.6E+02	3.6E+02	1.7E-01	1.3E-01
Hour 21	2.6E+02	2.6E+02	1.3E-01	9.3E-02
Hour 22	2.1E+02	2.1E+02	1.0E-01	7.6E-02

Table H-185: Hourly Air Emissions from Microturbine (EC) in a Typical Day in August (ELF).

Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	6.5E-03	6.3E-03	6.1E-03	5.8E-03	7.3E-03	1.9E-02	2.6E-02	2.8E-02	2.7E-02
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehyd	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	1.4E-08	1.3E-08	1.3E-08	1.2E-08	1.5E-08	3.9E-08	5.5E-08	5.9E-08	5.8E-08
H2S	3.2E-07	3.1E-07	2.9E-07	2.8E-07	3.5E-07	9.0E-07	1.3E-06	1.3E-06	1.3E-06
NMVOC	9.3E-04	9.0E-04	8.6E-04	8.2E-04	1.0E-03	2.6E-03	3.7E-03	3.9E-03	3.9E-03
CO	5.9E-02	5.7E-02	5.5E-02	5.3E-02	6.6E-02	1.7E-01	2.4E-01	2.5E-01	2.5E-01
Particulates	9.1E-04	8.8E-04	8.5E-04	8.1E-04	1.0E-03	2.6E-03	3.6E-03	3.9E-03	3.8E-03
HF	1.7E-05	1.7E-05	1.6E-05	1.5E-05	1.9E-05	4.8E-05	6.8E-05	7.2E-05	7.1E-05
HCl	1.7E-04	1.6E-04	1.6E-04	1.5E-04	1.9E-04	4.8E-04	6.6E-04	7.1E-04	7.0E-04
NOx	3.1E-02	3.0E-02	2.9E-02	2.8E-02	3.5E-02	8.9E-02	1.2E-01	1.3E-01	1.3E-01
SO2	5.2E-03	5.0E-03	4.8E-03	4.6E-03	5.8E-03	1.5E-02	2.1E-02	2.2E-02	2.2E-02
SO2	2.7E-02	2.6E-02	2.5E-02	2.4E-02	3.0E-02	7.7E-02	1.1E-01	1.1E-01	1.1E-01
TOPP eq.	4.9E-02	4.7E-02	4.5E-02	4.3E-02	5.5E-02	1.4E-01	1.9E-01	2.1E-01	2.0E-01
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.9E-02	3.1E-02	3.1E-02	3.1E-02	3.3E-02	3.3E-02	2.7E-02	2.0E-02	1.3E-02	9.8E-03	7.9E-03
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
6.1E-08	6.7E-08	6.8E-08	6.6E-08	7.1E-08	7.1E-08	5.8E-08	4.2E-08	2.9E-08	2.1E-08	1.7E-08
1.4E-06	1.5E-06	1.5E-06	1.5E-06	1.6E-06	1.6E-06	1.3E-06	9.5E-07	6.4E-07	4.7E-07	3.9E-07
4.1E-03	4.4E-03	4.5E-03	4.4E-03	4.7E-03	4.6E-03	3.8E-03	2.8E-03	1.9E-03	1.4E-03	1.1E-03
2.6E-01	2.8E-01	2.9E-01	2.8E-01	3.0E-01	3.0E-01	2.4E-01	1.8E-01	1.2E-01	8.9E-02	7.2E-02
4.0E-03	4.4E-03	4.4E-03	4.3E-03	4.6E-03	4.6E-03	3.7E-03	2.8E-03	1.9E-03	1.4E-03	1.1E-03
7.5E-05	8.1E-05	8.2E-05	8.0E-05	8.6E-05	8.5E-05	7.0E-05	5.1E-05	3.5E-05	2.6E-05	2.1E-05
7.3E-04	7.9E-04	8.1E-04	7.9E-04	8.5E-04	8.4E-04	6.8E-04	5.0E-04	3.4E-04	2.5E-04	2.0E-04
1.4E-01	1.5E-01	1.5E-01	1.5E-01	1.6E-01	1.6E-01	1.3E-01	9.4E-02	6.3E-02	4.7E-02	3.8E-02
2.3E-02	2.5E-02	2.5E-02	2.5E-02	2.6E-02	2.6E-02	2.1E-02	1.6E-02	1.1E-02	7.8E-03	6.3E-03
1.2E-01	1.3E-01	1.3E-01	1.3E-01	1.4E-01	1.4E-01	1.1E-01	8.2E-02	5.5E-02	4.1E-02	3.3E-02
2.1E-01	2.3E-01	2.4E-01	2.3E-01	2.5E-01	2.5E-01	2.0E-01	1.5E-01	1.0E-01	7.3E-02	6.0E-02
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-186: Hourly GWP Emissions from Microturbine (EC) in a Typical Day in August (ELF).

Perfluoropenta	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropa	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclo	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethan	2.7E-10	2.6E-10	2.5E-10	2.4E-10	3.1E-10	7.8E-10	1.1E-09	1.2E-09	1.1E-09
Perfluorometha	2.2E-09	2.1E-09	2.0E-09	1.9E-09	2.4E-09	6.2E-09	8.6E-09	9.2E-09	9.1E-09
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.4E-04	1.3E-04	1.3E-04	1.2E-04	1.5E-04	3.9E-04	5.4E-04	5.8E-04	5.7E-04
CH4	2.5E-01	2.4E-01	2.3E-01	2.2E-01	2.7E-01	7.0E-01	9.7E-01	1.0E+00	1.0E+00
CO2	6.4E+01	6.2E+01	5.9E+01	5.6E+01	7.1E+01	1.8E+02	2.5E+02	2.7E+02	2.6E+02
CO2	6.9E+01	6.7E+01	6.4E+01	6.1E+01	7.7E+01	2.0E+02	2.7E+02	2.9E+02	2.9E+02
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
1.2E-09	1.3E-09	1.3E-09	1.3E-09	1.4E-09	1.4E-09	1.1E-09	8.3E-10	5.6E-10	4.1E-10	3.3E-10
9.6E-09	1.0E-08	1.1E-08	1.0E-08	1.1E-08	1.1E-08	9.0E-09	6.6E-09	4.5E-09	3.3E-09	2.6E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
6.0E-04	6.5E-04	6.6E-04	6.5E-04	6.9E-04	6.9E-04	5.6E-04	4.1E-04	2.8E-04	2.1E-04	1.7E-04
1.1E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00	1.0E+00	7.4E-01	5.0E-01	3.7E-01	3.0E-01
2.8E+02	3.0E+02	3.1E+02	3.0E+02	3.2E+02	3.2E+02	2.6E+02	1.9E+02	1.3E+02	9.5E+01	7.7E+01
3.0E+02	3.3E+02	3.3E+02	3.2E+02	3.5E+02	3.4E+02	2.8E+02	2.1E+02	1.4E+02	1.0E+02	8.4E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-187: Hourly Primary Energy Consumption from Microturbine (EC) in a Typical Day in August (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	3.3E+02	3.3E+02	1.5E-01	1.2E-01
Hour 4	3.2E+02	3.2E+02	1.4E-01	1.1E-01
Hour 5	3.1E+02	3.0E+02	1.4E-01	1.1E-01
Hour 6	2.9E+02	2.9E+02	1.3E-01	1.0E-01
Hour 7	3.7E+02	3.7E+02	1.6E-01	1.3E-01
Hour 8	9.3E+02	9.3E+02	4.1E-01	3.3E-01
Hour 9	1.3E+03	1.3E+03	5.8E-01	4.6E-01
Hour 10	1.4E+03	1.4E+03	6.1E-01	4.9E-01
Hour 11	1.4E+03	1.4E+03	6.1E-01	4.9E-01
Hour 12	1.4E+03	1.4E+03	6.4E-01	5.2E-01
Hour 13	1.6E+03	1.6E+03	6.9E-01	5.6E-01
Hour 14	1.6E+03	1.6E+03	7.0E-01	5.7E-01
Hour 15	1.5E+03	1.5E+03	6.8E-01	5.5E-01
Hour 16	1.7E+03	1.7E+03	7.4E-01	6.0E-01
Hour 17	1.6E+03	1.6E+03	7.3E-01	5.9E-01
Hour 18	1.3E+03	1.3E+03	6.0E-01	4.8E-01
Hour 19	9.9E+02	9.9E+02	4.4E-01	3.5E-01
Hour 20	6.7E+02	6.7E+02	3.0E-01	2.4E-01
Hour 21	4.9E+02	4.9E+02	2.2E-01	1.8E-01
Hour 22	4.0E+02	4.0E+02	1.8E-01	1.4E-01

Table H-188: Hourly Air Emissions from Microturbine (AC/EC) in a Typical Day in August (ELF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
TOPP eq.	4.1E-02	3.9E-02	3.7E-02	3.5E-02	4.4E-02	1.1E-01	1.6E-01	1.6E-01	1.6E-01
SO2	2.3E-02	2.2E-02	2.0E-02	1.9E-02	2.4E-02	6.1E-02	8.7E-02	8.7E-02	8.7E-02
SO2	4.3E-03	4.1E-03	3.9E-03	3.7E-03	4.7E-03	1.2E-02	1.7E-02	1.7E-02	1.7E-02
NOx	2.6E-02	2.5E-02	2.3E-02	2.2E-02	2.8E-02	7.0E-02	1.0E-01	1.0E-01	1.0E-01
HCl	1.4E-04	1.3E-04	1.3E-04	1.2E-04	1.5E-04	3.7E-04	5.3E-04	5.3E-04	5.3E-04
HF	1.4E-05	1.4E-05	1.3E-05	1.2E-05	1.5E-05	3.8E-05	5.4E-05	5.4E-05	5.4E-05
Particulates	7.6E-04	7.2E-04	6.8E-04	6.5E-04	8.2E-04	2.0E-03	2.9E-03	2.9E-03	2.9E-03
CO	4.9E-02	4.7E-02	4.4E-02	4.2E-02	5.4E-02	1.3E-01	1.9E-01	1.9E-01	1.9E-01
NMVOC	7.7E-04	7.4E-04	6.9E-04	6.6E-04	8.4E-04	2.1E-03	3.0E-03	3.0E-03	3.0E-03
H2S	2.6E-07	2.5E-07	2.4E-07	2.3E-07	2.9E-07	7.1E-07	1.0E-06	1.0E-06	1.0E-06
NH3	1.1E-08	1.1E-08	1.0E-08	9.6E-09	1.2E-08	3.0E-08	4.3E-08	4.3E-08	4.3E-08
Acetaldehyd	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	5.4E-03	5.2E-03	4.9E-03	4.7E-03	5.9E-03	1.5E-02	2.1E-02	2.1E-02	2.1E-02
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.1E-02	2.2E-02	2.2E-02	2.1E-02	2.3E-02	2.3E-02	1.9E-02	1.4E-02	9.3E-03	7.3E-03	6.3E-03
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.3E-08	4.5E-08	4.5E-08	4.4E-08	4.8E-08	4.7E-08	3.9E-08	2.8E-08	1.9E-08	1.5E-08	1.3E-08
1.0E-06	1.1E-06	1.1E-06	1.0E-06	1.1E-06	1.1E-06	9.1E-07	6.7E-07	4.5E-07	3.5E-07	3.1E-07
3.0E-03	3.1E-03	3.1E-03	3.0E-03	3.3E-03	3.2E-03	2.7E-03	1.9E-03	1.3E-03	1.0E-03	8.9E-04
1.9E-01	2.0E-01	2.0E-01	2.0E-01	2.1E-01	2.1E-01	1.7E-01	1.2E-01	8.5E-02	6.6E-02	5.7E-02
2.9E-03	3.0E-03	3.1E-03	3.0E-03	3.2E-03	3.2E-03	2.6E-03	1.9E-03	1.3E-03	1.0E-03	8.7E-04
5.4E-05	5.7E-05	5.7E-05	5.6E-05	6.0E-05	6.0E-05	4.9E-05	3.6E-05	2.4E-05	1.9E-05	1.6E-05
5.3E-04	5.6E-04	5.6E-04	5.5E-04	5.9E-04	5.9E-04	4.8E-04	3.5E-04	2.4E-04	1.9E-04	1.6E-04
1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.1E-01	1.1E-01	8.9E-02	6.6E-02	4.5E-02	3.5E-02	3.0E-02
1.7E-02	1.7E-02	1.8E-02	1.7E-02	1.8E-02	1.8E-02	1.5E-02	1.1E-02	7.4E-03	5.8E-03	5.0E-03
8.7E-02	9.0E-02	9.1E-02	8.9E-02	9.6E-02	9.5E-02	7.8E-02	5.7E-02	3.9E-02	3.0E-02	2.6E-02
1.6E-01	1.6E-01	1.6E-01	1.6E-01	1.7E-01	1.7E-01	1.4E-01	1.0E-01	7.0E-02	5.5E-02	4.7E-02
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-189: Hourly GWP Emissions from Microturbine (AC/EC) in a Typical Day in August (ELF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclobu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethane	2.2E-10	2.1E-10	2.0E-10	1.9E-10	2.4E-10	6.0E-10	8.5E-10	8.5E-10	8.5E-10
Perfluoromethan	1.8E-09	1.7E-09	1.6E-09	1.5E-09	1.9E-09	4.7E-09	6.8E-09	6.8E-09	6.8E-09
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.1E-04	1.1E-04	1.0E-04	9.8E-05	1.2E-04	3.1E-04	4.4E-04	4.4E-04	4.4E-04
CH4	2.0E-01	2.0E-01	1.8E-01	1.7E-01	2.2E-01	5.5E-01	7.8E-01	7.8E-01	7.8E-01
CO2	5.3E+01	5.1E+01	4.8E+01	4.5E+01	5.7E+01	1.4E+02	2.0E+02	2.0E+02	2.0E+02
CO2 Equivalent	5.7E+01	5.5E+01	5.2E+01	4.9E+01	6.2E+01	1.5E+02	2.2E+02	2.2E+02	2.2E+02

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
8.5E-10	8.9E-10	9.0E-10	8.8E-10	9.5E-10	9.4E-10	7.7E-10	5.6E-10	3.8E-10	3.0E-10	2.6E-10
6.8E-09	7.0E-09	7.1E-09	7.0E-09	7.5E-09	7.5E-09	6.1E-09	4.5E-09	3.0E-09	2.4E-09	2.0E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.4E-04	4.6E-04	4.6E-04	4.5E-04	4.9E-04	4.8E-04	3.9E-04	2.9E-04	2.0E-04	1.5E-04	1.3E-04
7.8E-01	8.1E-01	8.2E-01	8.1E-01	8.7E-01	8.6E-01	7.0E-01	5.2E-01	3.5E-01	2.7E-01	2.4E-01
2.0E+02	2.1E+02	2.1E+02	2.1E+02	2.3E+02	2.2E+02	1.8E+02	1.3E+02	9.1E+01	7.1E+01	6.1E+01
2.2E+02	2.3E+02	2.3E+02	2.3E+02	2.4E+02	2.4E+02	2.0E+02	1.4E+02	9.8E+01	7.7E+01	6.6E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-190: Hourly Primary Energy Consumption from Microturbine (AC/EC) in a Typical Day in August (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.73E+02	2.73E+02	1.21E-01	9.49E-02
Hour 4	2.62E+02	2.61E+02	1.16E-01	9.09E-02
Hour 5	2.46E+02	2.46E+02	1.09E-01	8.54E-02
Hour 6	2.34E+02	2.34E+02	1.04E-01	8.14E-02
Hour 7	2.97E+02	2.97E+02	1.31E-01	1.03E-01
Hour 8	7.34E+02	7.34E+02	3.25E-01	2.55E-01
Hour 9	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 10	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 11	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 12	1.05E+03	1.05E+03	4.65E-01	3.65E-01
Hour 13	1.09E+03	1.09E+03	4.83E-01	3.78E-01
Hour 14	1.11E+03	1.11E+03	4.90E-01	3.84E-01
Hour 15	1.08E+03	1.08E+03	4.79E-01	3.76E-01
Hour 16	1.17E+03	1.16E+03	5.16E-01	4.05E-01
Hour 17	1.15E+03	1.15E+03	5.11E-01	4.01E-01
Hour 18	9.43E+02	9.42E+02	4.17E-01	3.27E-01
Hour 19	6.92E+02	6.92E+02	3.06E-01	2.40E-01
Hour 20	4.69E+02	4.69E+02	2.08E-01	1.63E-01
Hour 21	3.67E+02	3.67E+02	1.62E-01	1.27E-01
Hour 22	3.16E+02	3.16E+02	1.40E-01	1.10E-01

Table H-191: Hourly Air Emissions from 3-MW ICE (EC) in a Typical Day in August (ELF).

Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	6.5E-05	6.3E-05	6.0E-05	5.8E-05	7.3E-05	1.8E-04	2.6E-04	2.7E-04	2.7E-04
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	1.9E-04	1.8E-04	1.7E-04	1.6E-04	2.1E-04	5.3E-04	7.4E-04	7.9E-04	7.7E-04
TOC	5.3E-04	5.1E-04	4.9E-04	4.7E-04	5.9E-04	1.5E-03	2.1E-03	2.2E-03	2.2E-03
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	1.3E-01	1.3E-01	1.2E-01	1.2E-01	1.5E-01	3.7E-01	5.2E-01	5.5E-01	5.4E-01
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehyd	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	1.1E-08	1.0E-08	1.0E-08	9.5E-09	1.2E-08	3.1E-08	4.3E-08	4.6E-08	4.5E-08
H2S	2.3E-07	2.2E-07	2.1E-07	2.0E-07	2.5E-07	6.5E-07	9.0E-07	9.6E-07	9.5E-07
NMVOC	4.3E-03	4.2E-03	4.0E-03	3.8E-03	4.8E-03	1.2E-02	1.7E-02	1.8E-02	1.8E-02
CO	3.2E-01	3.1E-01	2.9E-01	2.8E-01	3.5E-01	9.0E-01	1.3E+00	1.3E+00	1.3E+00
Particulates	3.9E-03	3.7E-03	3.6E-03	3.4E-03	4.3E-03	1.1E-02	1.5E-02	1.6E-02	1.6E-02
HF	1.2E-05	1.2E-05	1.1E-05	1.1E-05	1.4E-05	3.5E-05	4.9E-05	5.2E-05	5.1E-05
HCl	1.2E-04	1.2E-04	1.1E-04	1.1E-04	1.3E-04	3.4E-04	4.8E-04	5.1E-04	5.0E-04
NOx	4.6E-02	4.4E-02	4.3E-02	4.1E-02	5.1E-02	1.3E-01	1.8E-01	1.9E-01	1.9E-01
SO2	3.6E-03	3.5E-03	3.4E-03	3.2E-03	4.1E-03	1.0E-02	1.4E-02	1.5E-02	1.5E-02
SO2	3.6E-02	3.5E-02	3.3E-02	3.2E-02	4.0E-02	1.0E-01	1.4E-01	1.5E-01	1.5E-01
TOPP eq.	9.8E-02	9.5E-02	9.1E-02	8.7E-02	1.1E-01	2.8E-01	3.9E-01	4.1E-01	4.1E-01
Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.9E-04	3.1E-04	3.1E-04	3.1E-04	3.3E-04	3.3E-04	2.7E-04	2.0E-04	1.3E-04	9.7E-05	7.9E-05
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
8.2E-04	8.8E-04	9.0E-04	8.7E-04	9.4E-04	9.3E-04	7.6E-04	5.6E-04	3.8E-04	2.8E-04	2.3E-04
2.3E-03	2.5E-03	2.5E-03	2.5E-03	2.7E-03	2.6E-03	2.2E-03	1.6E-03	1.1E-03	7.9E-04	6.4E-04
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.7E-01	6.2E-01	6.3E-01	6.1E-01	6.6E-01	6.5E-01	5.3E-01	3.9E-01	2.6E-01	1.9E-01	1.6E-01
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.8E-08	5.2E-08	5.3E-08	5.2E-08	5.6E-08	5.6E-08	4.5E-08	3.3E-08	2.3E-08	1.6E-08	1.3E-08
1.0E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	9.3E-07	6.8E-07	4.6E-07	3.4E-07	2.8E-07
1.9E-02	2.1E-02	2.1E-02	2.0E-02	2.2E-02	2.2E-02	1.8E-02	1.3E-02	8.8E-03	6.5E-03	5.3E-03
1.4E+00	1.5E+00	1.5E+00	1.5E+00	1.6E+00	1.6E+00	1.3E+00	9.5E-01	6.5E-01	4.7E-01	3.9E-01
1.7E-02	1.8E-02	1.9E-02	1.8E-02	1.9E-02	1.9E-02	1.6E-02	1.2E-02	7.8E-03	5.8E-03	4.7E-03
5.4E-05	5.8E-05	5.9E-05	5.8E-05	6.2E-05	6.1E-05	5.0E-05	3.7E-05	2.5E-05	1.8E-05	1.5E-05
5.3E-04	5.7E-04	5.8E-04	5.7E-04	6.1E-04	6.0E-04	4.9E-04	3.6E-04	2.4E-04	1.8E-04	1.5E-04
2.0E-01	2.2E-01	2.2E-01	2.2E-01	2.3E-01	2.3E-01	1.9E-01	1.4E-01	9.3E-02	6.9E-02	5.6E-02
1.6E-02	1.7E-02	1.8E-02	1.7E-02	1.8E-02	1.8E-02	1.5E-02	1.1E-02	7.4E-03	5.5E-03	4.4E-03
1.6E-01	1.7E-01	1.7E-01	1.7E-01	1.8E-01	1.8E-01	1.5E-01	1.1E-01	7.3E-02	5.3E-02	4.3E-02
4.3E-01	4.7E-01	4.7E-01	4.6E-01	5.0E-01	4.9E-01	4.0E-01	3.0E-01	2.0E-01	1.5E-01	1.2E-01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-192: Hourly GWP Emissions from 3-MW ICE (EC) in a Typical Day in August (ELF).

Option [kg]	Hour 3	Hour 4	hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
Perfluoropenta	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropa	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclo	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethan	2.1E-10	2.0E-10	2.0E-10	1.9E-10	2.4E-10	6.0E-10	8.4E-10	9.0E-10	8.8E-10
Perfluorometha	1.7E-09	1.6E-09	1.6E-09	1.5E-09	1.9E-09	4.8E-09	6.7E-09	7.2E-09	7.0E-09
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.3E-03	1.3E-03	1.2E-03	1.2E-03	1.5E-03	3.8E-03	5.2E-03	5.6E-03	5.5E-03
CH4	2.1E-01	2.0E-01	1.9E-01	1.8E-01	2.3E-01	5.9E-01	8.2E-01	8.7E-01	8.6E-01
CO2	3.9E+01	3.7E+01	3.6E+01	3.4E+01	4.3E+01	1.1E+02	1.5E+02	1.6E+02	1.6E+02
CO2	4.3E+01	4.2E+01	4.0E+01	3.8E+01	4.9E+01	1.2E+02	1.7E+02	1.8E+02	1.8E+02

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
9.4E-10	1.0E-09	1.0E-09	1.0E-09	1.1E-09	1.1E-09	8.8E-10	6.5E-10	4.4E-10	3.2E-10	2.6E-10
7.5E-09	8.1E-09	8.3E-09	8.0E-09	8.7E-09	8.6E-09	7.0E-09	5.2E-09	3.5E-09	2.5E-09	2.1E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.8E-03	6.3E-03	6.4E-03	6.2E-03	6.7E-03	6.6E-03	5.4E-03	4.0E-03	2.7E-03	2.0E-03	1.6E-03
9.1E-01	9.8E-01	1.0E+00	9.7E-01	1.0E+00	1.0E+00	8.5E-01	6.2E-01	4.2E-01	3.1E-01	2.5E-01
1.7E+02	1.8E+02	1.9E+02	1.8E+02	2.0E+02	1.9E+02	1.6E+02	1.2E+02	7.9E+01	5.8E+01	4.7E+01
1.9E+02	2.1E+02	2.1E+02	2.0E+02	2.2E+02	2.2E+02	1.8E+02	1.3E+02	8.8E+01	6.5E+01	5.3E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-193: Hourly Primary Energy Consumption from 3-MW ICE (EC) in a Typical Day in August (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.4E+02	2.4E+02	1.1E-01	9.4E-02
Hour 4	2.3E+02	2.3E+02	1.0E-01	9.1E-02
hour 5	2.2E+02	2.2E+02	9.7E-02	8.8E-02
Hour 6	2.1E+02	2.1E+02	9.3E-02	8.4E-02
Hour 7	2.6E+02	2.6E+02	1.2E-01	1.1E-01
Hour 8	6.7E+02	6.7E+02	3.0E-01	2.7E-01
Hour 9	9.4E+02	9.3E+02	4.2E-01	3.7E-01
Hour 10	1.0E+03	1.0E+03	4.4E-01	4.0E-01
Hour 11	9.8E+02	9.8E+02	4.4E-01	3.9E-01
Hour 12	1.0E+03	1.0E+03	4.6E-01	4.2E-01
Hour 13	1.1E+03	1.1E+03	5.0E-01	4.6E-01
Hour 14	1.1E+03	1.1E+03	5.1E-01	4.6E-01
Hour 15	1.1E+03	1.1E+03	4.9E-01	4.5E-01
Hour 16	1.2E+03	1.2E+03	5.3E-01	4.9E-01
Hour 17	1.2E+03	1.2E+03	5.3E-01	4.8E-01
Hour 18	9.7E+02	9.6E+02	4.3E-01	3.9E-01
Hour 19	7.1E+02	7.1E+02	3.2E-01	2.9E-01
Hour 20	4.8E+02	4.8E+02	2.1E-01	2.0E-01
Hour 21	3.5E+02	3.5E+02	1.6E-01	1.4E-01
Hour 22	2.9E+02	2.9E+02	1.3E-01	1.2E-01

Table H-194: Hourly Air Emissions from 3-MW ICE (AC/EC) in a Typical Day in August (ELF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	5.7E-05	5.5E-05	5.3E-05	5.1E-05	6.4E-05	1.6E-04	2.3E-04	2.4E-04	2.4E-04
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	1.6E-04	1.6E-04	1.5E-04	1.5E-04	1.8E-04	4.7E-04	6.5E-04	6.9E-04	6.8E-04
TOC	4.6E-04	4.5E-04	4.3E-04	4.1E-04	5.2E-04	1.3E-03	1.8E-03	2.0E-03	1.9E-03
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	1.1E-01	1.1E-01	1.1E-01	1.0E-01	1.3E-01	3.3E-01	4.5E-01	4.8E-01	4.8E-01
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehyd	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	9.2E-09	8.8E-09	8.6E-09	8.2E-09	1.0E-08	2.6E-08	3.6E-08	3.9E-08	3.8E-08
H2S	2.0E-07	1.9E-07	1.9E-07	1.8E-07	2.2E-07	5.7E-07	7.9E-07	8.5E-07	8.3E-07
NMVOC	3.8E-03	3.7E-03	3.6E-03	3.4E-03	4.3E-03	1.1E-02	1.5E-02	1.6E-02	1.6E-02
CO	2.8E-01	2.7E-01	2.6E-01	2.5E-01	3.1E-01	8.0E-01	1.1E+00	1.2E+00	1.2E+00
Particulates	3.4E-03	3.2E-03	3.2E-03	3.0E-03	3.8E-03	9.6E-03	1.3E-02	1.4E-02	1.4E-02
HF	1.1E-05	1.0E-05	1.0E-05	9.6E-06	1.2E-05	3.1E-05	4.3E-05	4.6E-05	4.5E-05
HCl	1.1E-04	1.0E-04	9.9E-05	9.4E-05	1.2E-04	3.0E-04	4.2E-04	4.5E-04	4.4E-04
NOx	4.0E-02	3.9E-02	3.8E-02	3.6E-02	4.5E-02	1.2E-01	1.6E-01	1.7E-01	1.7E-01
SO2	3.2E-03	3.1E-03	3.0E-03	2.9E-03	3.6E-03	9.1E-03	1.3E-02	1.4E-02	1.3E-02
SO2	3.1E-02	3.0E-02	2.9E-02	2.8E-02	3.5E-02	9.0E-02	1.2E-01	1.3E-01	1.3E-01
TOPP eq.	8.6E-02	8.3E-02	8.0E-02	7.7E-02	9.7E-02	2.5E-01	3.4E-01	3.6E-01	3.6E-01

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.5E-04	2.7E-04	2.8E-04	2.7E-04	2.9E-04	2.9E-04	2.4E-04	1.7E-04	1.2E-04	8.6E-05	7.0E-05
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
7.2E-04	7.8E-04	8.0E-04	7.8E-04	8.4E-04	8.3E-04	6.8E-04	5.0E-04	3.4E-04	2.5E-04	2.0E-04
2.0E-03	2.2E-03	2.3E-03	2.2E-03	2.4E-03	2.4E-03	1.9E-03	1.4E-03	9.5E-04	7.0E-04	5.6E-04
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.0E-01	5.5E-01	5.6E-01	5.4E-01	5.9E-01	5.8E-01	4.7E-01	3.5E-01	2.4E-01	1.7E-01	1.4E-01
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.1E-08	4.4E-08	4.5E-08	4.4E-08	4.7E-08	4.7E-08	3.8E-08	2.8E-08	1.9E-08	1.4E-08	1.1E-08
8.8E-07	9.6E-07	9.7E-07	9.5E-07	1.0E-06	1.0E-06	8.3E-07	6.1E-07	4.1E-07	3.0E-07	2.4E-07
1.7E-02	1.8E-02	1.9E-02	1.8E-02	2.0E-02	1.9E-02	1.6E-02	1.2E-02	7.8E-03	5.7E-03	4.6E-03
1.2E+00	1.3E+00	1.4E+00	1.3E+00	1.4E+00	1.4E+00	1.2E+00	8.5E-01	5.7E-01	4.2E-01	3.4E-01
1.5E-02	1.6E-02	1.6E-02	1.6E-02	1.7E-02	1.7E-02	1.4E-02	1.0E-02	6.9E-03	5.1E-03	4.1E-03
4.7E-05	5.2E-05	5.2E-05	5.1E-05	5.5E-05	5.5E-05	4.5E-05	3.3E-05	2.2E-05	1.6E-05	1.3E-05
4.7E-04	5.1E-04	5.1E-04	5.0E-04	5.4E-04	5.4E-04	4.4E-04	3.2E-04	2.2E-04	1.6E-04	1.3E-04
1.8E-01	1.9E-01	2.0E-01	1.9E-01	2.1E-01	2.0E-01	1.7E-01	1.2E-01	8.3E-02	6.1E-02	4.9E-02
1.4E-02	1.5E-02	1.6E-02	1.5E-02	1.6E-02	1.6E-02	1.3E-02	9.7E-03	6.6E-03	4.8E-03	3.9E-03
1.4E-01	1.5E-01	1.5E-01	1.5E-01	1.6E-01	1.6E-01	1.3E-01	9.5E-02	6.4E-02	4.7E-02	3.8E-02
3.8E-01	4.1E-01	4.2E-01	4.1E-01	4.4E-01	4.4E-01	3.6E-01	2.6E-01	1.8E-01	1.3E-01	1.0E-01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-195: Hourly GWP Emissions from 3-MW ICE (AC/EC) in a Typical Day in August (ELF).

Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclobuta	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethane	1.8E-10	1.7E-10	1.7E-10	1.6E-10	2.0E-10	5.2E-10	7.1E-10	7.7E-10	7.5E-10
Perfluoromethane	1.4E-09	1.4E-09	1.3E-09	1.3E-09	1.6E-09	4.1E-09	5.7E-09	6.1E-09	6.0E-09
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.2E-03	1.1E-03	1.1E-03	1.0E-03	1.3E-03	3.3E-03	4.6E-03	4.9E-03	4.8E-03
CH4	1.8E-01	1.7E-01	1.7E-01	1.6E-01	2.0E-01	5.2E-01	7.2E-01	7.7E-01	7.5E-01
CO2	3.4E+01	3.3E+01	3.2E+01	3.0E+01	3.8E+01	9.7E+01	1.3E+02	1.4E+02	1.4E+02
CO2 Equivalent	3.8E+01	3.7E+01	3.6E+01	3.4E+01	4.3E+01	1.1E+02	1.5E+02	1.6E+02	1.6E+02
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
8.0E-10	8.7E-10	8.8E-10	8.6E-10	9.3E-10	9.2E-10	7.5E-10	5.5E-10	3.7E-10	2.7E-10	2.2E-10
6.3E-09	6.9E-09	7.0E-09	6.8E-09	7.4E-09	7.3E-09	6.0E-09	4.4E-09	3.0E-09	2.2E-09	1.8E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.1E-03	5.6E-03	5.7E-03	5.5E-03	6.0E-03	5.9E-03	4.8E-03	3.5E-03	2.4E-03	1.7E-03	1.4E-03
8.0E-01	8.7E-01	8.9E-01	8.6E-01	9.3E-01	9.2E-01	7.5E-01	5.5E-01	3.7E-01	2.7E-01	2.2E-01
1.5E+02	1.6E+02	1.7E+02	1.6E+02	1.7E+02	1.7E+02	1.4E+02	1.0E+02	7.0E+01	5.1E+01	4.1E+01
1.7E+02	1.8E+02	1.9E+02	1.8E+02	2.0E+02	1.9E+02	1.6E+02	1.2E+02	7.9E+01	5.7E+01	4.6E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-196: Hourly Primary Energy Consumption from 3-MW ICE (AC/EC) in a Typical Day in August (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.1E+02	2.1E+02	9.2E-02	8.1E-02
Hour 4	2.0E+02	2.0E+02	8.9E-02	7.8E-02
Hour 5	1.9E+02	1.9E+02	8.6E-02	7.6E-02
Hour 6	1.9E+02	1.9E+02	8.2E-02	7.2E-02
Hour 7	2.3E+02	2.3E+02	1.0E-01	9.1E-02
Hour 8	5.9E+02	5.9E+02	2.6E-01	2.3E-01
Hour 9	8.2E+02	8.2E+02	3.6E-01	3.2E-01
Hour 10	8.8E+02	8.8E+02	3.9E-01	3.4E-01
Hour 11	8.6E+02	8.6E+02	3.8E-01	3.4E-01
Hour 12	9.2E+02	9.1E+02	4.1E-01	3.6E-01
Hour 13	9.9E+02	9.9E+02	4.4E-01	3.9E-01
Hour 14	1.0E+03	1.0E+03	4.5E-01	3.9E-01
Hour 15	9.9E+02	9.8E+02	4.4E-01	3.8E-01
Hour 16	1.1E+03	1.1E+03	4.7E-01	4.2E-01
Hour 17	1.1E+03	1.1E+03	4.7E-01	4.1E-01
Hour 18	8.6E+02	8.6E+02	3.8E-01	3.4E-01
Hour 19	6.3E+02	6.3E+02	2.8E-01	2.5E-01
Hour 20	4.3E+02	4.3E+02	1.9E-01	1.7E-01
Hour 21	3.1E+02	3.1E+02	1.4E-01	1.2E-01
Hour 22	2.5E+02	2.5E+02	1.1E-01	9.9E-02

Table H-197: Hourly Air Emissions from 143-kW ICE (EC) in a Typical Day in August (ELF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	6.5E-05	6.3E-05	6.0E-05	5.8E-05	7.3E-05	1.8E-04	2.6E-04	2.7E-04	2.7E-04
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	1.9E-04	1.8E-04	1.7E-04	1.6E-04	2.1E-04	5.3E-04	7.4E-04	7.9E-04	7.7E-04
TOC	5.3E-04	5.1E-04	4.9E-04	4.7E-04	5.9E-04	1.5E-03	2.1E-03	2.2E-03	2.2E-03
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	1.3E-01	1.3E-01	1.2E-01	1.2E-01	1.5E-01	3.7E-01	5.2E-01	5.5E-01	5.4E-01
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehyd	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	1.3E-08	1.3E-08	1.2E-08	1.2E-08	1.5E-08	3.8E-08	5.3E-08	5.7E-08	5.6E-08
H2S	3.0E-07	2.9E-07	2.8E-07	2.7E-07	3.4E-07	8.6E-07	1.2E-06	1.3E-06	1.3E-06
NMVOC	5.8E-03	5.6E-03	5.4E-03	5.1E-03	6.5E-03	1.6E-02	2.3E-02	2.4E-02	2.4E-02
CO	4.2E-01	4.1E-01	3.9E-01	3.7E-01	4.7E-01	1.2E+00	1.7E+00	1.8E+00	1.8E+00
Particulates	5.1E-03	4.9E-03	4.7E-03	4.5E-03	5.7E-03	1.4E-02	2.0E-02	2.2E-02	2.1E-02
HF	1.6E-05	1.6E-05	1.5E-05	1.4E-05	1.8E-05	4.6E-05	6.5E-05	6.9E-05	6.8E-05
HCl	1.6E-04	1.5E-04	1.5E-04	1.4E-04	1.8E-04	4.5E-04	6.3E-04	6.8E-04	6.7E-04
NOx	6.1E-02	5.9E-02	5.7E-02	5.4E-02	6.8E-02	1.7E-01	2.4E-01	2.6E-01	2.5E-01
SO2	4.8E-03	4.7E-03	4.5E-03	4.3E-03	5.4E-03	1.4E-02	1.9E-02	2.0E-02	2.0E-02
SO2	4.7E-02	4.6E-02	4.4E-02	4.2E-02	5.3E-02	1.3E-01	1.9E-01	2.0E-01	2.0E-01
TOPP eq.	1.3E-01	1.3E-01	1.2E-01	1.2E-01	1.5E-01	3.7E-01	5.2E-01	5.5E-01	5.4E-01

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.9E-04	3.1E-04	3.1E-04	3.1E-04	3.3E-04	3.3E-04	2.7E-04	2.0E-04	1.3E-04	9.7E-05	7.9E-05
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
8.2E-04	8.8E-04	9.0E-04	8.7E-04	9.4E-04	9.3E-04	7.6E-04	5.6E-04	3.8E-04	2.8E-04	2.3E-04
2.3E-03	2.5E-03	2.5E-03	2.5E-03	2.7E-03	2.6E-03	2.2E-03	1.6E-03	1.1E-03	7.9E-04	6.4E-04
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.7E-01	6.2E-01	6.3E-01	6.1E-01	6.6E-01	6.5E-01	5.3E-01	3.9E-01	2.6E-01	1.9E-01	1.6E-01
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5.9E-08	6.5E-08	6.6E-08	6.4E-08	6.9E-08	6.9E-08	5.6E-08	4.1E-08	2.8E-08	2.0E-08	1.6E-08
1.3E-06	1.4E-06	1.5E-06	1.4E-06	1.5E-06	1.5E-06	1.2E-06	9.1E-07	6.2E-07	4.5E-07	3.7E-07
2.5E-02	2.7E-02	2.8E-02	2.7E-02	2.9E-02	2.9E-02	2.4E-02	1.7E-02	1.2E-02	8.6E-03	7.0E-03
1.9E+00	2.0E+00	2.0E+00	2.0E+00	2.1E+00	2.1E+00	1.7E+00	1.3E+00	8.6E-01	6.3E-01	5.1E-01
2.2E-02	2.4E-02	2.5E-02	2.4E-02	2.6E-02	2.6E-02	2.1E-02	1.5E-02	1.0E-02	7.6E-03	6.2E-03
7.2E-05	7.7E-05	7.8E-05	7.7E-05	8.2E-05	8.2E-05	6.7E-05	4.9E-05	3.3E-05	2.4E-05	2.0E-05
7.0E-04	7.6E-04	7.7E-04	7.5E-04	8.1E-04	8.0E-04	6.5E-04	4.8E-04	3.3E-04	2.4E-04	1.9E-04
2.7E-01	2.9E-01	2.9E-01	2.9E-01	3.1E-01	3.1E-01	2.5E-01	1.8E-01	1.2E-01	9.1E-02	7.4E-02
2.1E-02	2.3E-02	2.3E-02	2.3E-02	2.4E-02	2.4E-02	2.0E-02	1.4E-02	9.8E-03	7.2E-03	5.9E-03
2.1E-01	2.3E-01	2.3E-01	2.2E-01	2.4E-01	2.4E-01	1.9E-01	1.4E-01	9.6E-02	7.1E-02	5.8E-02
5.7E-01	6.2E-01	6.3E-01	6.1E-01	6.6E-01	6.5E-01	5.3E-01	3.9E-01	2.7E-01	2.0E-01	1.6E-01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-198: Hourly GWP Emissions from 143-kW ICE (EC) in a Typical Day in August (ELF).

Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11
CO2 Equivalent	5.8E+01	5.6E+01	5.4E+01	5.1E+01	6.5E+01	1.6E+02	2.3E+02	2.4E+02	2.4E+02
CO2	5.2E+01	5.0E+01	4.8E+01	4.6E+01	5.8E+01	1.5E+02	2.0E+02	2.2E+02	2.1E+02
CH4	2.8E-01	2.7E-01	2.6E-01	2.4E-01	3.1E-01	7.8E-01	1.1E+00	1.2E+00	1.1E+00
N2O	1.8E-03	1.7E-03	1.6E-03	1.6E-03	2.0E-03	5.0E-03	7.0E-03	7.4E-03	7.3E-03
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-10mee	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoromethan	2.1E-09	2.0E-09	1.9E-09	1.9E-09	2.3E-09	6.0E-09	8.3E-09	8.9E-09	8.7E-09
Perfluoroethane	2.6E-10	2.5E-10	2.4E-10	2.3E-10	2.9E-10	7.5E-10	1.0E-09	1.1E-09	1.1E-09
Perfluorocyclobu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropentan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
1.2E-09	1.3E-09	1.3E-09	1.3E-09	1.4E-09	1.3E-09	1.1E-09	8.0E-10	5.5E-10	4.0E-10	3.2E-10
9.3E-09	1.0E-08	1.0E-08	1.0E-08	1.1E-08	1.1E-08	8.7E-09	6.4E-09	4.3E-09	3.2E-09	2.6E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
7.7E-03	8.3E-03	8.5E-03	8.3E-03	8.9E-03	8.8E-03	7.2E-03	5.3E-03	3.6E-03	2.6E-03	2.1E-03
1.2E+00	1.3E+00	1.3E+00	1.3E+00	1.4E+00	1.4E+00	1.1E+00	8.3E-01	5.6E-01	4.1E-01	3.3E-01
2.3E+02	2.4E+02	2.5E+02	2.4E+02	2.6E+02	2.6E+02	2.1E+02	1.5E+02	1.0E+02	7.7E+01	6.3E+01
2.5E+02	2.7E+02	2.8E+02	2.7E+02	2.9E+02	2.9E+02	2.4E+02	1.7E+02	1.2E+02	8.6E+01	7.0E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-199: Hourly Primary Energy Consumption from 143-kW ICE (EC) in a Typical Day in August (ELF).

Option [kWh]	Sum	non renewable	Renewable	other
Hour 3	3.1E+02	3.1E+02	1.4E-01	1.1E-01
Hour 4	3.0E+02	3.0E+02	1.3E-01	1.1E-01
Hour 5	2.9E+02	2.9E+02	1.3E-01	1.0E-01
Hour 6	2.8E+02	2.8E+02	1.2E-01	1.0E-01
Hour 7	3.5E+02	3.5E+02	1.6E-01	1.3E-01
Hour 8	8.9E+02	8.9E+02	4.0E-01	3.2E-01
Hour 9	1.2E+03	1.2E+03	5.5E-01	4.5E-01
Hour 10	1.3E+03	1.3E+03	5.9E-01	4.8E-01
Hour 11	1.3E+03	1.3E+03	5.8E-01	4.7E-01
Hour 12	1.4E+03	1.4E+03	6.1E-01	5.0E-01
Hour 13	1.5E+03	1.5E+03	6.6E-01	5.4E-01
Hour 14	1.5E+03	1.5E+03	6.7E-01	5.5E-01
Hour 15	1.5E+03	1.5E+03	6.5E-01	5.4E-01
Hour 16	1.6E+03	1.6E+03	7.0E-01	5.8E-01
Hour 17	1.6E+03	1.6E+03	7.0E-01	5.8E-01
Hour 18	1.3E+03	1.3E+03	5.7E-01	4.7E-01
Hour 19	9.5E+02	9.4E+02	4.2E-01	3.4E-01
Hour 20	6.4E+02	6.4E+02	2.8E-01	2.3E-01
Hour 21	4.7E+02	4.7E+02	2.1E-01	1.7E-01
Hour 22	3.8E+02	3.8E+02	1.7E-01	1.4E-01

Table H-200: Hourly Air Emissions from 143-kW ICE (AC/EC) in a Typical Day in August (ELF).

Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xylene	5.4E-05	5.2E-05	4.9E-05	4.6E-05	5.9E-05	1.5E-04	2.1E-04	2.2E-04	2.2E-04
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
VOC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Vanadium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Toluene	1.5E-04	1.5E-04	1.4E-04	1.3E-04	1.7E-04	4.2E-04	6.0E-04	6.3E-04	6.2E-04
TOC	4.4E-04	4.2E-04	3.9E-04	3.8E-04	4.8E-04	1.2E-03	1.7E-03	1.8E-03	1.8E-03
Selenium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PAH	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Molybdenu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methane	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mercury	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HC	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cobalt	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Beryllium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	1.1E-01	1.0E-01	9.8E-02	9.3E-02	1.2E-01	3.0E-01	4.2E-01	4.4E-01	4.3E-01
Barium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acrolein	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Acetaldehyd	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NH3	1.1E-08	1.0E-08	9.7E-09	9.3E-09	1.2E-08	3.0E-08	4.2E-08	4.4E-08	4.3E-08
H2S	2.5E-07	2.4E-07	2.3E-07	2.2E-07	2.7E-07	6.9E-07	9.7E-07	1.0E-06	1.0E-06
NMVOC	4.8E-03	4.6E-03	4.3E-03	4.1E-03	5.2E-03	1.3E-02	1.8E-02	2.0E-02	1.9E-02
CO	3.5E-01	3.4E-01	3.2E-01	3.0E-01	3.8E-01	9.6E-01	1.3E+00	1.4E+00	1.4E+00
Particulates	4.2E-03	4.1E-03	3.8E-03	3.6E-03	4.6E-03	1.2E-02	1.6E-02	1.7E-02	1.7E-02
HF	1.4E-05	1.3E-05	1.2E-05	1.2E-05	1.5E-05	3.7E-05	5.2E-05	5.5E-05	5.4E-05
HCl	1.3E-04	1.3E-04	1.2E-04	1.1E-04	1.4E-04	3.6E-04	5.1E-04	5.4E-04	5.3E-04
NOx	5.1E-02	4.9E-02	4.6E-02	4.3E-02	5.5E-02	1.4E-01	2.0E-01	2.1E-01	2.0E-01
SO2	4.0E-03	3.8E-03	3.6E-03	3.4E-03	4.3E-03	1.1E-02	1.5E-02	1.6E-02	1.6E-02
SO2	3.9E-02	3.8E-02	3.6E-02	3.4E-02	4.3E-02	1.1E-01	1.5E-01	1.6E-01	1.6E-01
TOPP eq.	1.1E-01	1.0E-01	9.8E-02	9.3E-02	1.2E-01	3.0E-01	4.2E-01	4.4E-01	4.3E-01
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2.3E-04	2.5E-04	2.6E-04	2.5E-04	2.7E-04	2.7E-04	2.2E-04	1.6E-04	1.1E-04	7.8E-05	6.3E-05
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
6.6E-04	7.2E-04	7.3E-04	7.1E-04	7.7E-04	7.7E-04	6.2E-04	4.6E-04	3.1E-04	2.2E-04	1.8E-04
1.9E-03	2.0E-03	2.1E-03	2.0E-03	2.2E-03	2.2E-03	1.8E-03	1.3E-03	8.8E-04	6.3E-04	5.1E-04
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.6E-01	5.0E-01	5.1E-01	5.0E-01	5.4E-01	5.4E-01	4.4E-01	3.2E-01	2.2E-01	1.6E-01	1.3E-01
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4.6E-08	5.0E-08	5.1E-08	5.0E-08	5.4E-08	5.3E-08	4.4E-08	3.2E-08	2.2E-08	1.6E-08	1.3E-08
1.1E-06	1.2E-06	1.2E-06	1.2E-06	1.3E-06	1.2E-06	1.0E-06	7.4E-07	5.0E-07	3.6E-07	3.0E-07
2.0E-02	2.2E-02	2.3E-02	2.2E-02	2.4E-02	2.4E-02	1.9E-02	1.4E-02	9.6E-03	6.9E-03	5.6E-03
1.5E+00	1.6E+00	1.7E+00	1.6E+00	1.7E+00	1.7E+00	1.4E+00	1.0E+00	7.0E-01	5.1E-01	4.1E-01
1.8E-02	2.0E-02	2.0E-02	1.9E-02	2.1E-02	2.1E-02	1.7E-02	1.2E-02	8.5E-03	6.1E-03	5.0E-03
5.8E-05	6.3E-05	6.4E-05	6.2E-05	6.8E-05	6.7E-05	5.5E-05	4.0E-05	2.7E-05	2.0E-05	1.6E-05
5.7E-04	6.2E-04	6.3E-04	6.1E-04	6.6E-04	6.6E-04	5.4E-04	3.9E-04	2.7E-04	1.9E-04	1.6E-04
2.2E-01	2.4E-01	2.4E-01	2.3E-01	2.5E-01	2.5E-01	2.0E-01	1.5E-01	1.0E-01	7.3E-02	5.9E-02
1.7E-02	1.9E-02	1.9E-02	1.8E-02	2.0E-02	2.0E-02	1.6E-02	1.2E-02	8.0E-03	5.8E-03	4.7E-03
1.7E-01	1.8E-01	1.9E-01	1.8E-01	2.0E-01	2.0E-01	1.6E-01	1.2E-01	7.9E-02	5.7E-02	4.6E-02
4.6E-01	5.0E-01	5.1E-01	5.0E-01	5.4E-01	5.4E-01	4.4E-01	3.2E-01	2.2E-01	1.6E-01	1.3E-01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-201: Hourly GWP Emissions from 143-kW ICE (AC/EC) in a Typical Day in August (ELF).

Perfluoropenta	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorobutan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoropropa	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorohexan	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluorocyclo	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Perfluoroethan	2.1E-10	2.1E-10	1.9E-10	1.8E-10	2.3E-10	5.9E-10	8.2E-10	8.7E-10	8.6E-10
Perfluorometha	1.7E-09	1.6E-09	1.5E-09	1.5E-09	1.9E-09	4.7E-09	6.6E-09	6.9E-09	6.8E-09
SF6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-245	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-143	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-152a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134a	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-134	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-125	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-43-	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-32	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
HFC-23	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
N2O	1.5E-03	1.4E-03	1.3E-03	1.3E-03	1.6E-03	4.0E-03	5.6E-03	6.0E-03	5.9E-03
CH4	2.3E-01	2.2E-01	2.1E-01	2.0E-01	2.5E-01	6.3E-01	8.8E-01	9.3E-01	9.2E-01
CO2	4.3E+01	4.1E+01	3.9E+01	3.7E+01	4.7E+01	1.2E+02	1.6E+02	1.7E+02	1.7E+02
CO2	4.8E+01	4.6E+01	4.3E+01	4.1E+01	5.2E+01	1.3E+02	1.8E+02	2.0E+02	1.9E+02
Option [kg]	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11

0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
9.1E-10	9.9E-10	1.0E-09	9.8E-10	1.1E-09	1.1E-09	8.6E-10	6.3E-10	4.3E-10	3.1E-10	2.5E-10
7.2E-09	7.9E-09	8.0E-09	7.8E-09	8.5E-09	8.4E-09	6.9E-09	5.0E-09	3.4E-09	2.5E-09	2.0E-09
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
6.2E-03	6.8E-03	6.9E-03	6.7E-03	7.3E-03	7.2E-03	5.9E-03	4.3E-03	2.9E-03	2.1E-03	1.7E-03
9.7E-01	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	9.2E-01	6.7E-01	4.6E-01	3.3E-01	2.7E-01
1.8E+02	2.0E+02	2.0E+02	2.0E+02	2.1E+02	2.1E+02	1.7E+02	1.3E+02	8.6E+01	6.2E+01	5.0E+01
2.0E+02	2.2E+02	2.3E+02	2.2E+02	2.4E+02	2.4E+02	1.9E+02	1.4E+02	9.6E+01	6.9E+01	5.6E+01
Hour 12	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22

Table H-202: Hourly Primary Energy Consumption from 143-kW ICE (AC/EC) in a Typical Day in August (ELF).

Option [kWh]	Sum	non renewable	renewable	other
Hour 3	2.6E+02	2.6E+02	1.2E-01	9.2E-02
Hour 4	2.5E+02	2.5E+02	1.1E-01	8.8E-02
Hour 5	2.4E+02	2.3E+02	1.0E-01	8.3E-02
Hour 6	2.2E+02	2.2E+02	9.9E-02	7.9E-02
Hour 7	2.8E+02	2.8E+02	1.3E-01	1.0E-01
Hour 8	7.2E+02	7.2E+02	3.2E-01	2.5E-01
Hour 9	1.0E+03	1.0E+03	4.4E-01	3.5E-01
Hour 10	1.1E+03	1.1E+03	4.7E-01	3.8E-01
Hour 11	1.0E+03	1.0E+03	4.6E-01	3.7E-01
Hour 12	1.1E+03	1.1E+03	4.9E-01	3.9E-01
Hour 13	1.2E+03	1.2E+03	5.4E-01	4.3E-01
Hour 14	1.2E+03	1.2E+03	5.5E-01	4.3E-01
Hour 15	1.2E+03	1.2E+03	5.3E-01	4.2E-01
Hour 16	1.3E+03	1.3E+03	5.8E-01	4.6E-01
Hour 17	1.3E+03	1.3E+03	5.7E-01	4.6E-01
Hour 18	1.1E+03	1.1E+03	4.7E-01	3.7E-01
Hour 19	7.7E+02	7.7E+02	3.4E-01	2.7E-01
Hour 20	5.2E+02	5.2E+02	2.3E-01	1.8E-01
Hour 21	3.8E+02	3.8E+02	1.7E-01	1.3E-01
Hour 22	3.1E+02	3.1E+02	1.4E-01	1.1E-01

APPENDIX I

Sensitivity Analysis

To determine the significance of material constituents of the chillers and chillers' efficiencies on the process performance, different material compositions and efficiencies were examined. The chiller was assumed to be made of the following materials options:

- 100% steel;
- 98% steel and 2% copper; and
- 95% steel and 5% copper.

To examine the chiller efficiencies, the following coefficient of performances (COP) were considered:

- 1.0 COP;
- 1.05 COP; and
- 1.1 COP.

Different scenarios were constructed to model these options and the environmental impacts of using the chiller for cooling were analyzed. From the analysis of the results, there was negligible difference between the different materials constituents with same COP's. For instance, as shown in Figure I-106, the GWP emissions from AC's providing cooling of 1.0E+6 kWh, and having COP's of 1.0 and made of 2% copper and 98% steel; 5% copper and 95% steel; and 100% steel were approximately equal. However, when analyzing the GWP emissions for AC made of same materials but having different COP's, the results showed some differences in emissions, as shown in Figure I-106, which indicated that as the COP of the AC increased the emissions decreased. However, when analyzing the annual results for energy use in the building, where AC's constituted one of the processes providing energy in addition to gas boiler, NGCC etc., the environmental impacts of the different COP of the chillers were approximately equal. The following two figures show examples of the results obtained from the sensitivity analysis of annual energy use in the building, where cooling was about 28% of the total energy use. Figure I-107 shows a comparison between GWP emissions resulting from energy systems using 1.05 COP absorption chillers for cooling, where chillers with different materials compositions were examined. Figure I-108 shows a comparison between GWP emissions resulting from energy systems using 98% steel and 2% copper absorption chillers for cooling, where chillers with different efficiencies were examined. In both cases, the GWP emissions resulting from the energy systems were approximately equal, which indicated that the contribution of the different materials constituents and COP's of chillers were negligible in the context of the overall emissions resulting from energy systems.

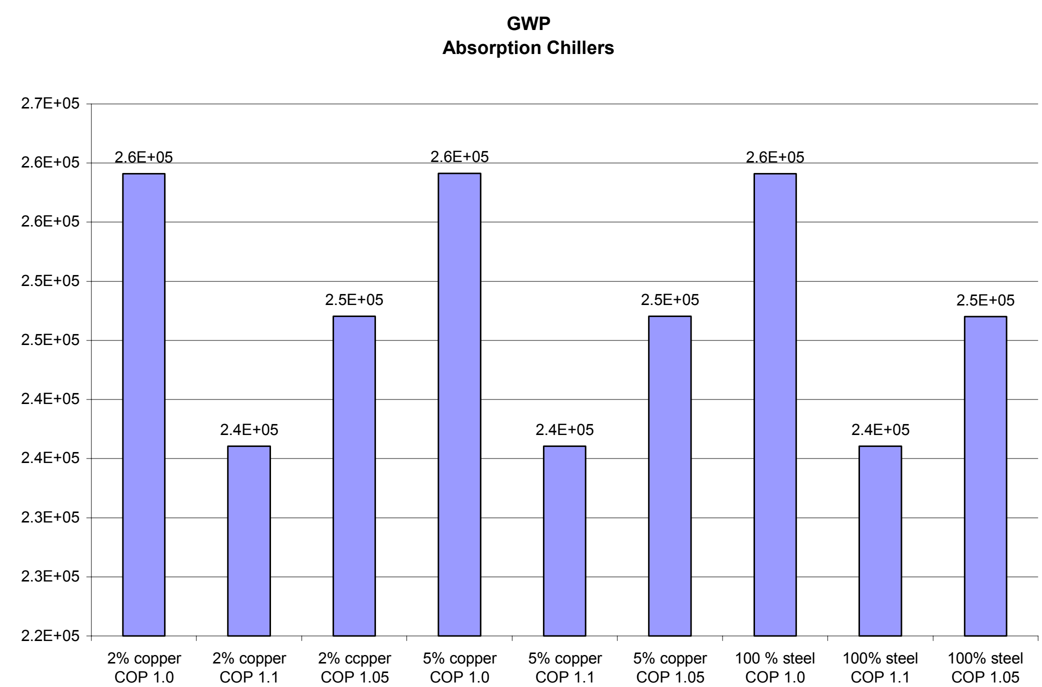

Figure I-106: GWP Emissions from Absorption Chillers Comparing Different COP and Materials.

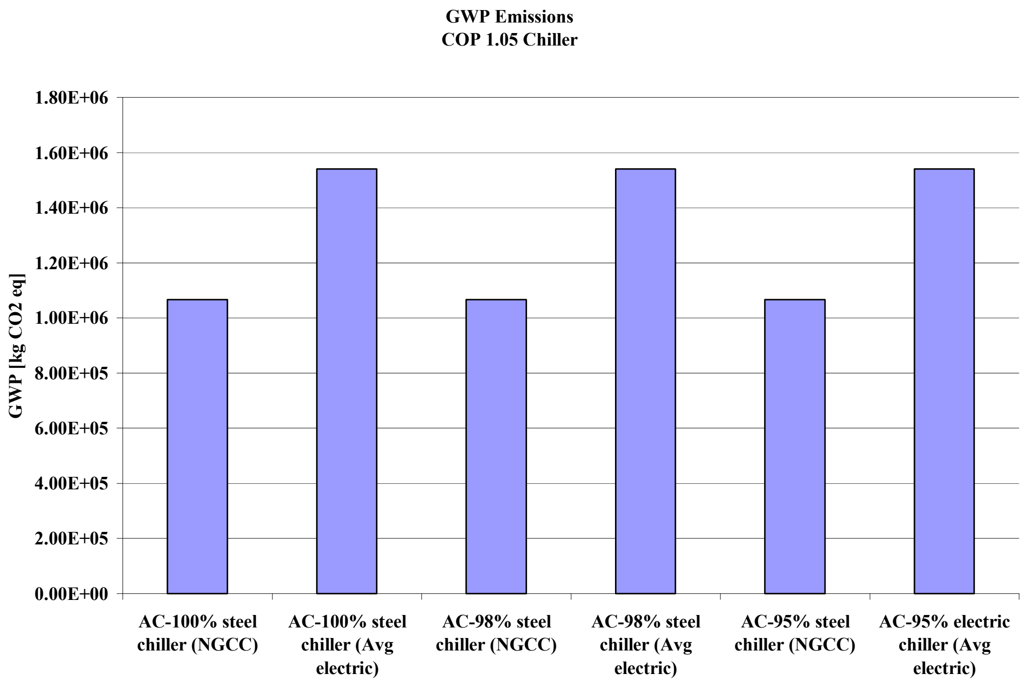

Figure I-107: GWP Emissions from Energy Systems Using 1.05 COP AC.

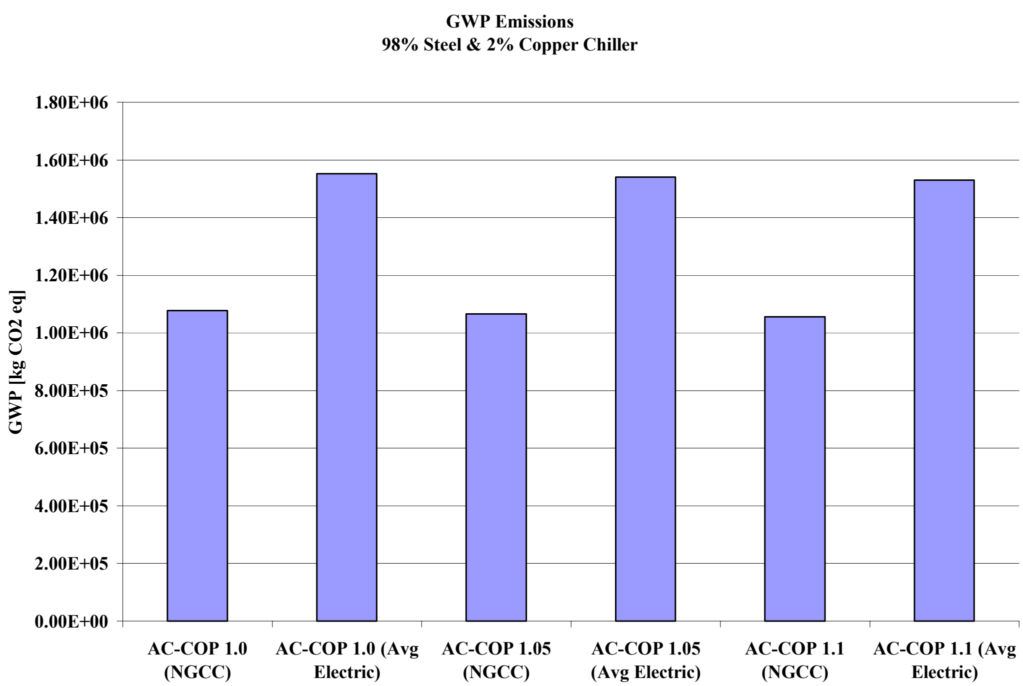

Figure I-108: GWP Emissions from Energy Systems Using 98% Steel AC.

APPENDIX J

Process Trees

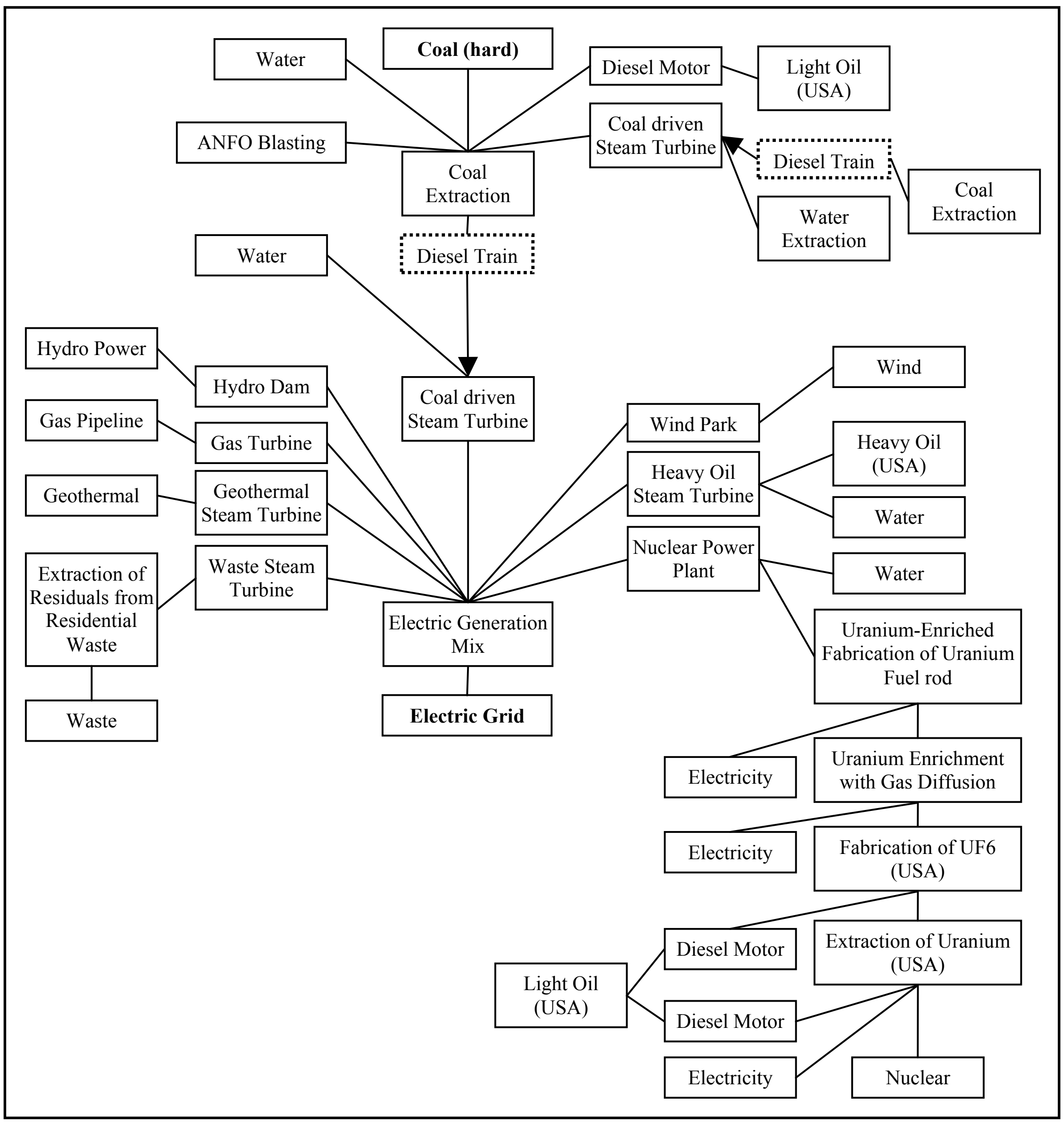

Figure J-109: Electricity Generation Mix (USA) Process Tree.

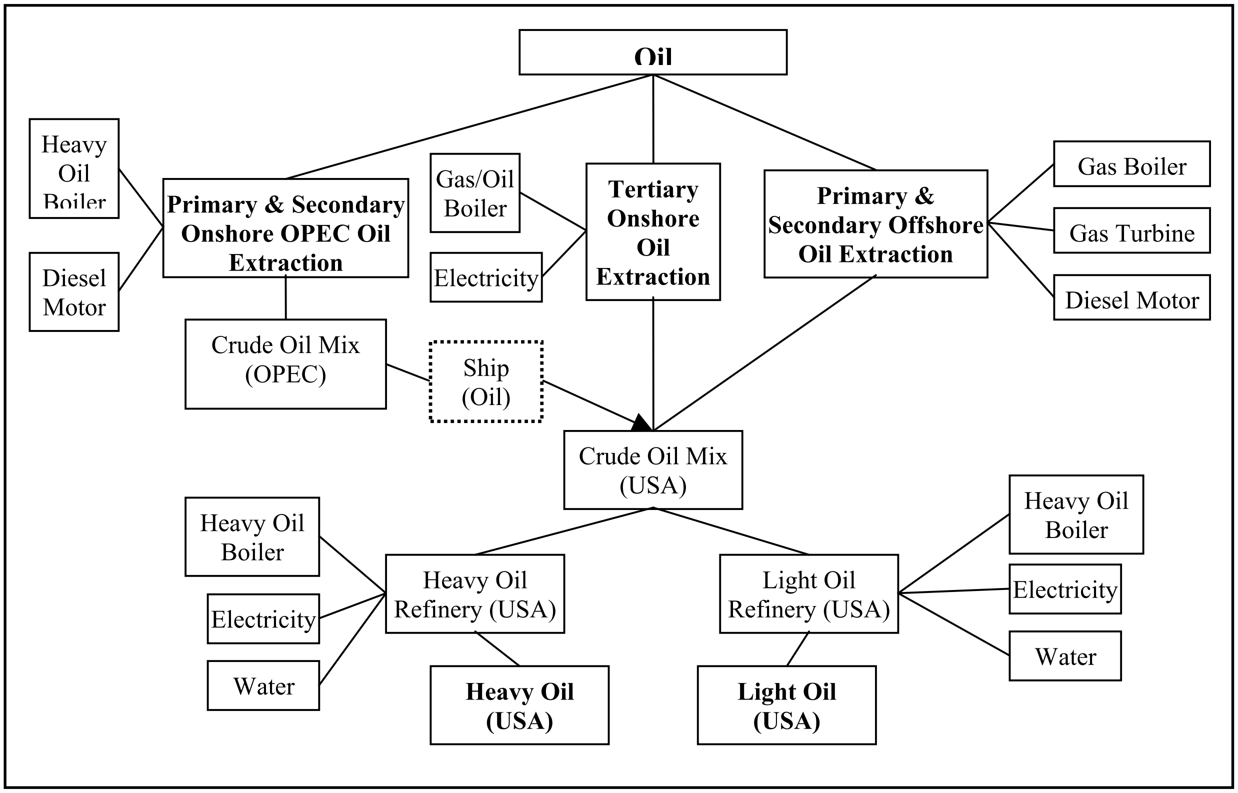

Figure J-110: Heavy and Light Oil Production (USA) Process Tree.

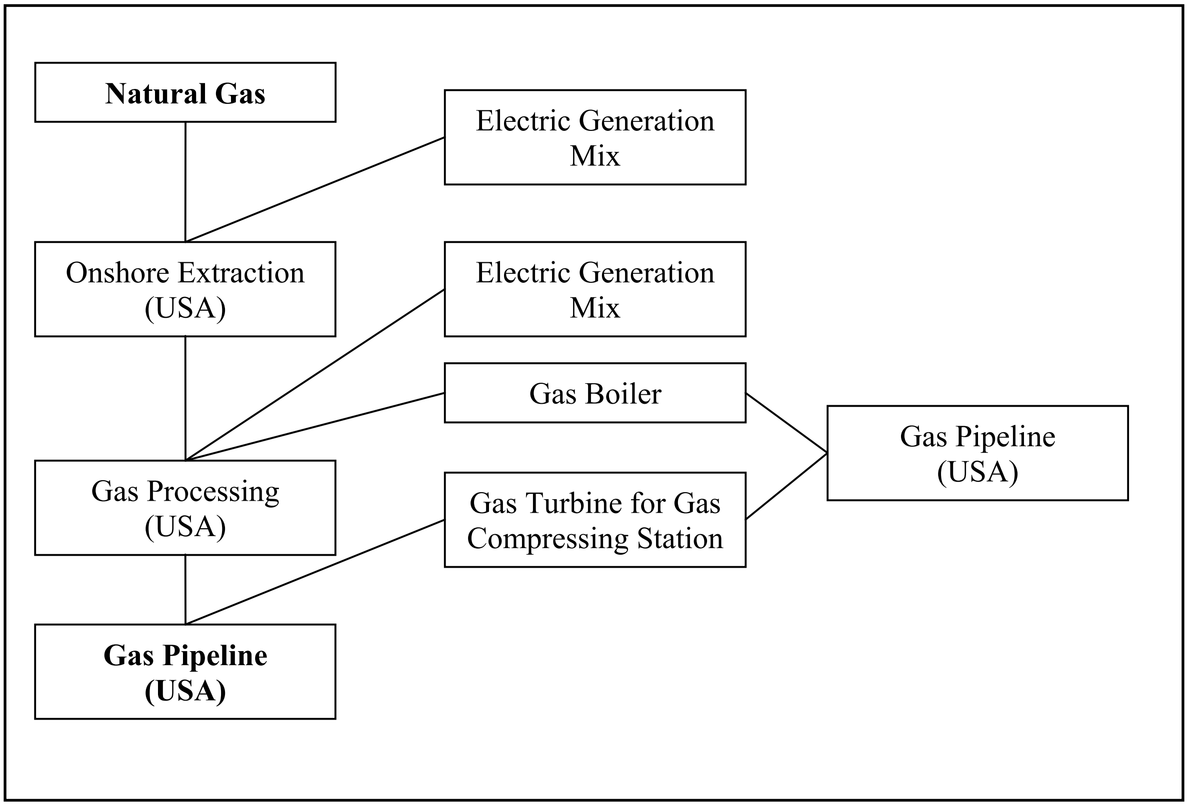

Figure J-111: Natural Gas Production (USA) Process Tree.

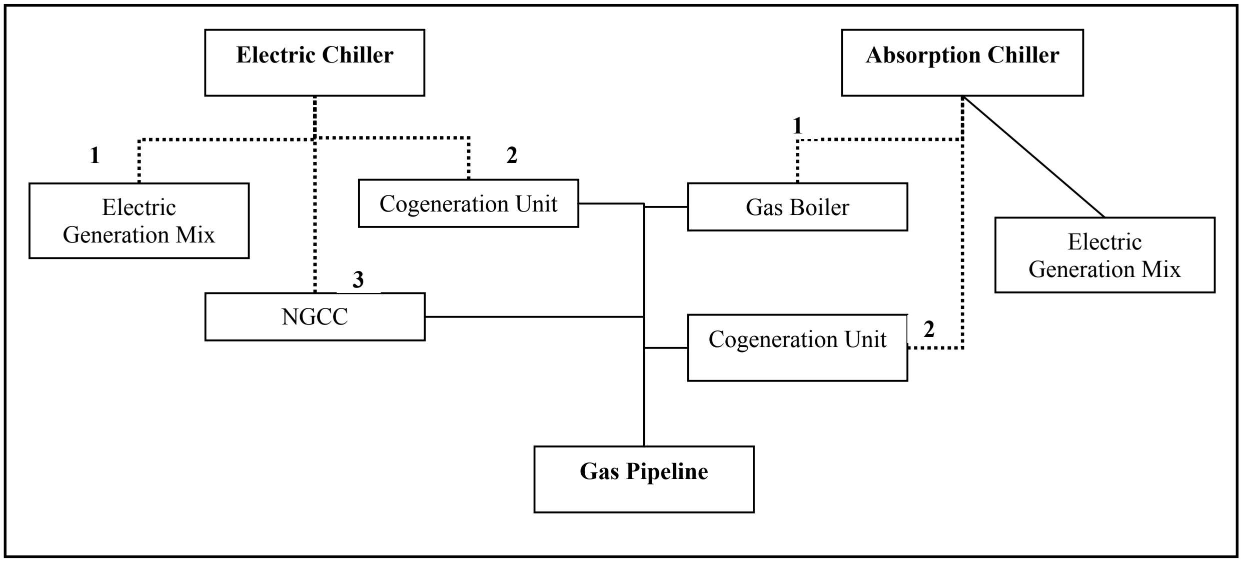

Figure J-112: Electric and Absorption Chillers Process Tree.

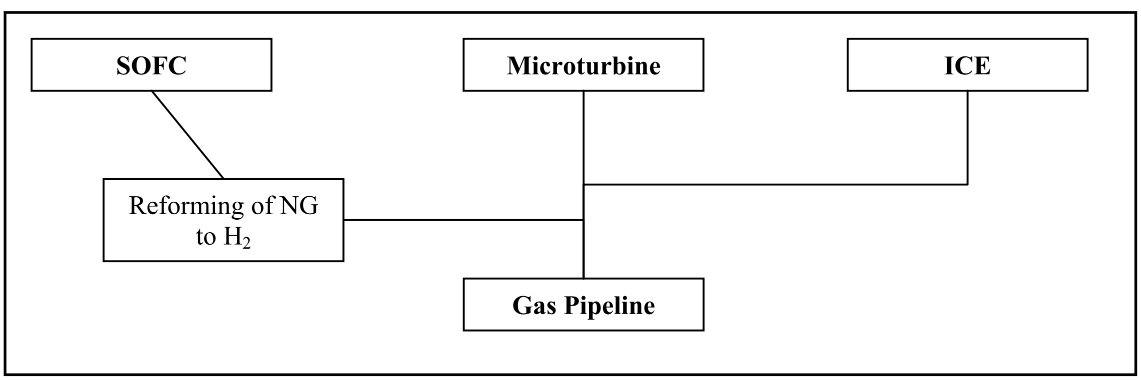

Figure J-113: Cogeneration Units Process Tree.

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